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Report to Congress on Special Wastes from Mineral Processing Summary and Findings, Methods and Analyses, Appendices

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This report addresses the following 8 study ractors required by Sectin 8002(p) of RCRA for the 20 mineral processing wastes: 1. the sources and volumes of such materials generated per year; 2. present disposal and utilization practices 3. potential danger to human health and the environment from the disposal and reuse of such materials; 4. documented cases in which danger to human health or hte environment has been proved; 5. alternatives to current disposal methods; 6. the costs of such alternatives; and 7. the impacts of these alternatives on the use of phosphate rock, uranium ore, and other natural resources; and 8. the current and potential utilization of such materials.

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Summary and Findings

1.0 Introduction

In October, 1980, the Resource Conservation and Recovery Act (RCRA) was amended by adding §3001(b)(3)(A)(ii) to exclude "solid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under Subtitle C of RCRA, pending completion of a study and a Report to Congress required by §8002(f) and (p) and a determination by the EPA Administrator either to promulgate regulations under Subtitle C or that such regulations are unwarranted (as required by §3001(b)(3)(C)). EPA modified its hazardous waste regulations in November 1980 to reflect this "Mining Waste Exclusion," and issued a preliminary, and quite broad, interpretation of the scope of its coverage. In particular, EPA interpreted the exclusion to include "solid waste from the exploration, mining, milling, smelting and refining of ores and minerals" (45 FR 76618, November 19, 1980).

In 1984, EPA was sued for failing to submit the Report to Congress and make the required regulatory determination by the statutory deadline (*Concerned Citizens of Adamstown v. EPA* No. 84-3041, D.D.C., August 21, 1985). In responding to this lawsuit, the Agency explained that it planned to propose a narrower interpretation of the scope of the Mining Waste Exclusion, so that it would encompass fewer wastes, and proposed to the Court two schedules: one for completing the §8002 studies of extraction and beneficiation wastes and submitting the Report to Congress for these wastes, and one for proposing and promulgating a reinterpretation for mineral processing wastes. In so doing, the Agency, in effect, split the wastes that might be eligible for exclusion from regulation into two groups: mining (mineral extraction and beneficiation) wastes, and mineral processing wastes. The Court agreed to this approach and established a schedule for the two tasks.

On December 31, 1985, EPA published the required Report to Congress on solid wastes from mineral extraction and beneficiation,[1] and on July 3, 1986 (51 FR 24496) published a determination that regulation of such wastes under Subtitle C of RCRA was not warranted. Since the determination was made, the Agency has been developing a tailored regulatory approach for these materials under the auspices of RCRA Subtitle D. In May, 1988, EPA issued a staff-level approach for regulating mining wastes (referred to as "Strawman") for public comment. More recently, the Agency issued a revised staff-level approach ("Strawman II") that incorporates comments from and responds to issues raised by the states, environmental groups, and the regulated community. The Agency is working to develop a formal proposal of a regulatory program for mineral extraction and beneficiation wastes.[2]

In keeping with its Court-ordered directive to reinterpret the Mining Waste Exclusion for mineral processing wastes, in October, 1985, EPA proposed to narrow the scope of the Exclusion for mineral processing wastes to include only a few specific waste streams. However, the Agency did not specify the criteria that it used to identify these materials, or to distinguish them from other wastes that were not eligible for the exclusion. In response to this proposal, many companies and industry organizations "nominated" wastes that they believed were eligible for the regulatory exemption. Faced with an inability at that time to articulate criteria that could be used to distinguish exempt from non-exempt wastes and the approaching Court-ordered deadline for final action, EPA withdrew its proposal on October 9, 1986.

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[1] U. S. Environmental Protection Agency, 1985. Report to Congress on Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale, EPA/530-SW-85-033, Washington, D.C. Available from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA. NTIS Document No. PB88-162631.

[2] The Agency has recently requested comments on Strawman II, including the appropriate scope of the program (i.e., which wastes should be covered).

In response to this action, the Agency was sued again. In July, 1988, the court in *Environmental Defense Fund v. EPA*, 852 F.2d 1316 (D. C. Cir. 1988), *cert. denied*, 109 S. Ct. 1120 (1989) ordered EPA to reinterpret the scope of the Exclusion for mineral processing wastes according to a new schedule. In particular, EPA was directed by the court to restrict the scope of the Exclusion as it applied to mineral processing wastes to include only "large volume, low hazard" wastes. In a series of rulemaking notices, EPA has, during the past two years, established the boundaries of the Mining Waste Exclusion for mineral processing wastes, and has articulated the criteria that were used to define "mineral processing" and to evaluate whether individual wastes are large volume and low hazard and, thus, eligible for the temporary exclusion provided by RCRA §3001(b)(3)(A)(ii). This rulemaking process was completed with the publication of a final rule on January 23, 1990 (55 FR 2322).[3] With the completion of these notices, the Agency established that the temporary exemption from Subtitle C requirements established by the Exclusion for mineral processing wastes and, therefore, the scope of this report, is limited to 20 mineral processing wastes generated by 91 facilities located in 29 states, representing 12 mineral commodity sectors. In particular, this report covers the following wastes:

- Alumina
  - red and brown muds from bauxite refining
- Chromium (Sodium chromate/dichromate)
  - treated residue from roasting/leaching of chrome ore
- Coal gas
  - gasifier ash from coal gasification
  - process wastewater from coal gasification
- Copper
  - slag from primary processing
  - calcium sulfate wastewater treatment plant sludge from primary processing
  - slag tailings from primary processing
- Elemental phosphorus
  - slag from primary production
- Ferrous metals (iron and carbon steel)
  - iron blast furnace air pollution control dust/sludge
  - iron blast furnace slag
  - basic oxygen furnace and open hearth furnace air pollution control dust/sludge
  - basic oxygen furnace and open hearth furnace slag
- Hydrofluoric acid
  - fluorogypsum
  - process wastewater
- Lead
  - slag from primary processing
- Magnesium
  - process wastewater from primary magnesium processing by the anhydrous process

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[3] This rulemaking process also included publication of a proposed rule on October 20, 1988 (53 FR 41288), a proposed rule on April 17, 1989 (54 FR 15316), a final rule on September 1, 1989 (54 FR 36592), and a proposed rule on September 25, 1989 (54 FR 39298).

- Phosphoric acid
  - phosphogypsum
  - process wastewater
- Titanium tetrachloride
  - chloride process waste solids
- Zinc
  - slag from primary processing

All other solid wastes from the processing of ores and minerals were removed from the Mining Waste Exclusion as of the effective date of the September 1, 1989 or January 23, 1990 final rules (March 1, 1990, or July 23, 1990 in non-authorized states), and are subject to regulation as hazardous wastes if they exhibit one or more characteristics of hazardous waste or are otherwise listed as hazardous waste.[4]

A summary of the important events in the rulemaking process and of the criteria that have been developed by the Agency to identify the 20 special wastes from mineral processing operations is presented in Appendix A to the report (contained in Volume III).

Following receipt and analysis of public comment on this report, the Agency will issue the regulatory determination required by RCRA §3001(b)(3)(C) that will either subject one or more of the 20 special mineral processing wastes to regulation under Subtitle C as hazardous wastes or conclude that such regulation is unwarranted. Wastes for which the Exclusion is retained will continue to be subject to regulation under RCRA Subtitle D as solid wastes. Our assessment of risk in this report has been based on a conservative set of risk assumptions. If additional regulation of these wastes is determined to be necessary, we would make such a determination with this in mind.

2.0 RCRA §8002(p) Study Factors

This report addresses the following eight study factors required by §8002(p) of RCRA for the 20 mineral processing wastes listed above:

1. The sources and volumes of such materials generated per year;
2. Present disposal and utilization practices;
3. Potential danger to human health and the environment from the disposal and reuse of such materials;
4. Documented cases in which danger to human health or the environment has been proved;
5. Alternatives to current disposal methods;
6. The costs of such alternatives;
7. The impacts of these alternatives on the use of phosphate rock, uranium ore, and other natural resources; and

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[4] Because the requirements of the September 1, 1989 and January 23, 1990 final rules were not imposed pursuant to the Hazardous and Solid Waste Amendments of 1984, they will not be effective in RCRA authorized states until the state program amendments are effective. Thus, the rules are effective on March 1, 1990 and July 23, 1990 (for the September 1, 1989 and January 23, 1990 rules, respectively) only in those states that do not have final authorization to operate their own hazardous waste programs in lieu of the Federal program. In authorized states, the rules are not applicable until the state revises its program to adopt equivalent requirements under state law and receives authorization for these new requirements. (Of course, the requirements will be applicable as state law if the state law is effective prior to authorization.) States that have final authorization must revise their programs to adopt equivalent standards regulating non-exempt mineral processing wastes that exhibit hazardous characteristics as hazardous by July 1, 1991 if regulatory changes only are necessary, or by July 1, 1992 if statutory changes are necessary. Once EPA approves the revision, the state requirements become RCRA Subtitle C requirements in that state.

8. The current and potential utilization of such materials.

The Agency's approach in preparing this report was to combine certain study factors for purposes of analysis and exposition. The resulting discussions, which are found in individual chapters (in Volume II) addressing each of the mineral commodity sectors, are organized in seven sections. The first section provides a brief overview of the industry, including the types of production processes used and the number and location of operating facilities that generate one or more mineral processing special wastes. The second section summarizes information on special waste characteristics, generation, and current management practices (study factors 1 and 2), while the third section provides a discussion of potential for and documented cases of danger to human health or the environment (study factors 3 and 4). The fourth section (as suggested by § 8002(p) of RCRA, independent of the eight study factors) summarizes applicable federal and state regulatory controls. The fifth section discusses alternative waste management practices and potential utilization of the wastes (study factors 5 and 8), while the sixth section discusses costs and impacts of alternative practices (study factors 6 and 7). The seventh and final section summarizes and analyzes the findings of EPA's evaluation of the above study factors.

3.0 Methods, Information Sources and Decision Rationale

In preparing this report, EPA has developed facility-specific data and analytical methods that reflect the complexity of the issues that are addressed herein. The facilities that generate the special study wastes vary considerably in the types of production operations and waste management techniques that they employ. Moreover, to examine in detail the broad array of study factors mandated by RCRA §8002(p), EPA had to develop approaches and methods that were sufficiently sophisticated to take into account the special nature of high volume mineral processing wastes. This section briefly outlines the data sources, methods, and decision rationale that the Agency employed to respond to the study factors.

3.1 EPA Data Collection Activities

EPA's Office of Solid Waste conducted a number of data collection activities to supplement and update previous work. The focus of most of these efforts was site-specific. As a consequence, EPA has been able to compile detailed facility- and sector-specific data bases, which the Agency has used extensively to prepare this report as well as a series of rulemakings which, as discussed above, have clarified the boundaries of the Mining Waste Exclusion as it applies to mineral processing wastes. The major information-gathering initiatives are as follows:

- Review of Public Comments
- 1989 National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF Survey)
- 1989 EPA Mineral Processing Waste Sampling and Analysis
- EPA Damage Case Collection
- EPA Site Visits
- RCRA §3007 Waste Characteristics Data Requests

These activities are described in more detail in Chapter 2 of Volume II, with additional discussion and/or examples provided in Appendix B, which is contained in Volume III.

3.2 Analytical Approach and Methods

This section summarizes EPA's approach for addressing each of the study factors.

Waste Characteristics, Generation, and Current Management Practices

To characterize the generation and management of each of the 20 special mineral processing wastes, EPA had to identify the facilities that generate the wastes, the production processes used and the products produced, the quantity and characteristics of the wastes generated, and the practices that are employed to manage them.

The identification of the facilities that generate one or more of the 20 special wastes was based upon prior EPA work, supplemented extensively by information provided by Commodity Specialists with the U.S Bureau of Mines. The operators of these facilities then were sent a survey questionnaire (SWMPF Survey) requesting information on waste generation and management. Survey responses allowed EPA to finalize its list of the active facilities in the mineral processing sectors of concern, and serve as the primary basis of EPA's understanding of the current management practices that are applied to special wastes from mineral processing operations.

Information submitted by industry in response to the SWMPF Survey was supplemented with and critically evaluated against data obtained from published sources, information collected as part of the damage case development process, and EPA observations made during waste sampling and other site visits. The descriptions of waste management practices provided in this report reflect EPA's synthesis of the information obtained during all of these information collection activities.

Potential and Documented Danger to Human Health and the Environment

Potential Danger to Human Health and the Environment

EPA conducted a facility-specific analysis of the risks associated with each of the 20 mineral processing wastes. The Agency collected information on the major factors that influence risks from the management of the special wastes at each of the 91 facilities that generate the wastes, and analyzed this information to develop conclusions on the potential for toxic constituents to be released from the waste and cause human health and environmental impacts. In a limited number of cases, EPA also conducted quantitative risk modeling to estimate potential danger to human health and the environment.

EPA employed a three step approach in this risk assessment, using each step as a means of narrowing the scope of the analysis to those wastes and facilities that pose the greatest potential risk. First, the Agency assessed the intrinsic hazard of the wastes by comparing the concentrations of toxic constituents in the wastes and in leachate from the wastes to screening criteria.[5] This step was used to determine which, if any, constituents of the special wastes may pose risks to human health and the environment based on reasonable, but conservative exposure assumptions. Second, EPA assessed the potential for toxic constituents from the subject wastes to cause damage at the 91 facilities by evaluating the practices currently used to manage the wastes and the environmental settings in which the wastes are managed. Using facility-specific information about special waste management and environmental setting, EPA then evaluated the potential for toxic or radioactive constituents to be released from the specific waste management units and to migrate to potential exposure points. Finally, for waste stream/environmental settings combinations at which risk potential appeared to be the greatest, EPA performed quantitative modeling to estimate the human health and environmental risks associated with existing waste management practices.

In all steps of the analysis, EPA focused on human health and environmental risks associated with chronic exposure to potential releases of waste constituents to ground water, surface water, and air. When possible, however, the Agency did evaluate the potential for large episodic releases of waste constituents (e.g., from storm or flood events) to endanger human health or the environment. To analyze risks to human health, the Agency evaluated the cancer and noncancer risks to maximally exposed individuals at each site. To analyze environmental risks, the Agency evaluated the potential for contaminants to migrate from the waste and adversely affect aquatic organisms. In addition to risks to human health and aquatic life, EPA also evaluated the potential for existing waste management practices to reduce the quality of water and air resources by considering the potential for air and water contamination, irrespective of the potential for humans or ecological receptors to be exposed to the contamination.

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[5] The focus of the screening criteria is on toxicity and radioactivity, in addition to a simple determination of corrosivity. EPA has sufficient knowledge of the characteristics of the 20 special mineral processing wastes to conclude that none are ignitable or reactive.

Documented Cases of Danger to Human Health or the Environment

Section 8002(p)(4) of RCRA requires that EPA's study of mineral processing wastes examine "documented cases in which danger to human health or the environment has been proved." In order to address this requirement, EPA defined danger to human health and the environment in the following way. First, danger to human health includes both acute and chronic effects associated with management of mineral processing wastes. Second, danger to the environment includes: (1) impairment of natural resources; (2) ecological effects resulting in impairment of the structure or function of natural ecosystems and habitats; and (3) effects on wildlife resulting in impairment to terrestrial or aquatic species.

The statutory requirement is that EPA examine "proven" cases of danger to human health or the environment. As a result, EPA developed a "test of proof" to be used for determining if documentation available on a case proves that danger/damage has occurred. This "test of proof" contains three separate tests; a case that satisfies one or more of these tests is considered "proven." The tests are as follows:

1. Scientific investigation: Damages are found to exist as part of the findings of a scientific study. Such studies include both extensive formal investigations supporting litigation or a State enforcement action and the results of technical tests (such as monitoring of wells). Scientific studies must demonstrate that damages are significant in terms of impacts on human health or the environment. For example, information on contamination of a drinking water aquifer must indicate that contamination levels exceed drinking water standards.

2. Administrative ruling: Damages are found to exist through a formal administrative ruling, such as the conclusions of a site report by a field inspector, or through existence of an enforcement action that cited specific health or environmental damages.

3. Court decision: Damages are found to exist through the ruling of a court or through an out-of-court settlement.

EPA has taken care in the course of preparing this evaluation to report only damages that are relevant to the decisions that will be based upon the Report to Congress (i.e., whether regulation of each of the special wastes from mineral processing under Subtitle C is appropriate). Consequently, the damage cases reported here are believed to be attributable (at least in part) to the special study wastes, and are believed to have resulted from management practices that are currently employed by active facilities in the commodity sectors of interest.

Existing Federal and State Waste Management Controls

In accordance with the suggestion in RCRA §8002(p), EPA has also examined other applicable federal and state waste management controls in an effort to minimize duplication.

Federal Controls

EPA's objective in this analysis was to identify and evaluate the existing regulatory controls over the management of special mineral processing wastes that have been promulgated by agencies of the federal government, focusing on programs and requirements established by EPA. This evaluation was performed for two reasons. First, some states do not have regulatory programs, meaning that federal requirements apply directly. Second, the federal government has not delegated authority to states for implementing some environmental protection statutes and regulations.

The initial phase of the analysis examined the relevant statutes and regulations pertaining to hazardous waste, solid waste, air quality, and water quality as they might apply to the management of the mineral processing special wastes, in general. The second phase of this analysis was to identify and evaluate any specific regulations that pertain to any of the 20 special mineral processing wastes. The final phase of the analysis involved contacting Regional EPA staff in those states that do not have federally approved programs for implementation of the major environmental statutes, as well as relevant staff within other federal agencies and departments, and performing a regulatory analysis of the implementation of all existing federal statutes and regulations that pertain specifically to the management of the 20 special mineral processing wastes. The findings of this review are contained within the twelve commodity-specific chapters, while descriptions of the major federal statutes and regulations that affect mineral processing wastes management generally are provided in Appendix D-1 (in Volume III).

Requirements in Selected States

EPA's goal in this analysis was to determine the current regulatory stance of states with regard to the mineral processing wastes generated by the 12 commodity sectors addressed in this report. The analysis serves more generally to help characterize current waste management and disposal practices taking place as a result of state regulation.

The first step in the analysis focused on reviewing material in a previous EPA-sponsored study on state-level regulation of mining and mineral processing wastes. The second step of EPA's analysis was to perform a more detailed review of individual state statutes and regulations; this review was limited in scope to a representative sample (18) of the 29 states containing facilities of interest for further analysis. While this more detailed study addressed, in part, the regulatory status of special mineral processing wastes, EPA found that the scope of state programs was not always clear from the state statutory and regulatory language that was reviewed. The final step of EPA's analysis, therefore, consisted of contacting state officials involved with the implementation of legal requirements in order to learn how those statutes and regulations are interpreted in practice, and to obtain facility-specific implementation information. The information compiled from these contacts was combined with the existing information on statutory and regulatory requirements to produce a final implementation analysis, which describes the existing regulatory structure applicable to the 20 mineral processing wastes generated by the twelve commodity sectors considered in this Report to Congress.

Alternative Management Practices and Potential Utilization

Section 8002(p) of the RCRA statute requires that EPA consider alternatives to current disposal methods, as well as the current and potential utilization of the wastes addressed by the Report to Congress. In order to accomplish this, this report identifies demonstrated alternatives for waste management and utilization. The costs, current use, potential use, and environmental impact of each alternative are evaluated to the extent permitted by the information available.

Because the primary purpose of this report is to determine whether the regulation of the special mineral processing wastes under Subtitle C is warranted, EPA focused its efforts and the discussion of waste management alternatives presented herein on those wastes that potentially may be candidates for Subtitle C regulation, excluding consideration of the costs and impacts of the various scenarios.

The focus of this analysis was on conducting a comprehensive computer-assisted literature search, then evaluating the information obtained thereby. In some instances, more detailed information was solicited from individual researchers, agencies, and trade associations. Detailed discussion of alternatives is limited in scope, however, to those for which information is adequate to assess their technical feasibility (i.e., EPA has not generally included alternatives that are experimental, unproven, or have not seen at least pilot-scale application).

Cost and Economic Impacts

Section 8002(p) of RCRA requires EPA to analyze "alternatives to current disposal methods" for solid wastes generated from the extraction, beneficiation, and processing of ores and minerals. EPA is also required to analyze "the costs of such alternatives." Section 6 of each commodity-specific chapter (in Volume II) discusses the costs and associated economic impacts of alternative waste management practices. The analysis of costs and impacts is limited in scope to those waste streams that exhibit one or more characteristics of hazardous waste and/or exhibit documented damage or potential risk.

The focus of the analysis is on the comparative operational and financial consequences of regulating these materials under various regulatory schemes. First, cost and impacts are calculated for regulation of these wastes under full Subtitle C of RCRA. Two less stringent regulatory scenarios are also considered, one of which reflects the potential for relaxed hazardous waste management controls found at §3004(x) of RCRA ("Subtitle C-Minus"), while the other is a hypothetical Subtitle D program designed to specifically address mineral processing wastes ("Subtitle D-Plus").

The incremental costs associated with alternative regulatory options are compared to several financial indicators at the facility level in order to determine the relative magnitude of potential impacts. In addition, the Agency has evaluated market conditions facing each affected facility and sector to assess the extent to which facilities potentially facing compliance costs would be able to pass through these costs to various product markets or force reductions in the cost of inputs (e.g., ore concentrate, labor).

In conducting this cost analysis, EPA has assumed, in most cases, that waste streams are potentially hazardous at only the individual facilities for which data submitted by industry or EPA sampling data indicate that the waste exhibits one or more of the four characteristics of a hazardous waste, as defined by 40 CFR Part 261 Subpart C. When wastes do exhibit a hazardous waste characteristic [illegible] is assumed that the waste(s) would be regulated as hazardous waste were it not for the exclusion provided by RCRA §3001(b)(3)(A)(ii), and the wastes are examined in the cost analysis accordingly.

3.3 Decision Rationale

EPA has developed two alternative approaches to analyze the information presented in this report regarding each of the 20 special wastes from mineral processing. Both approaches share a three-step process that the Agency used to evaluate the RCRA §8002(p) study factors by first assessing the need for additional regulatory controls (or absence thereof), then evaluating the options for appropriate requirements that could be applied to each individual waste stream for which additional controls might be in order, and, finally, estimate the associated costs and impacts. The second approach is distinguished from the first by the addition of a fourth step in which the Agency considered additional factors based on broader Agency goals and objectives. By applying this decision-making framework, consistent decisions regarding the need for additional regulatory controls for each of the 20 special study wastes were achieved.

In applying the decision criteria, EPA believes that the factors that are most important in establishing the regulatory status of the special wastes should be given major emphasis. Therefore, potential risks posed and documented damages caused by the wastes, the need for additional regulations, the costs and impacts that would be associated with more stringent regulatory controls, and overall Agency objectives are the focus of the four steps in the analysis process. The reason for this is that in the absence of potential risk and/or documented damages, there is no need for hazardous waste regulation under RCRA Subtitle C (the key issue in question); if greater regulatory controls are needed because of significant potential or documented danger, the costs and impacts of regulatory controls are the critical factors in determining whether a given alternative would lead to the desired outcome (adequate protection of human health and the environment and continued operation of the affected industries).

It should be noted that EPA has done its best to develop and analyze alternatives to current disposal methods. However, these scenarios represent an assessment of how regulatory requirements might be tailored to reflect the unusual characteristics of mineral processing wastes, that is, the assumptions made here in developing these scenarios may not resemble any actual Subtitle C-Minus or Subtitle D-Plus requirements that may be developed by the Agency in the future. As a result, EPA solicits comments on the regulatory scenarios that the Agency has used and the appropriateness of the underlying assumptions for the possible future development of regulatory programs under Subtitle D or under Subtitle C using the flexibility provided by RCRA §3004(x).

In considering whether Subtitle C regulation may be warranted or not, EPA is considering how or whether to implement the flexibility provided by RCRA §3004(x) to the extent that it can do so and continue to ensure human health and environmental protection. Specifically, EPA would consider this flexibility in establishing treatment standards for land disposal of these newly identified wastes under 40 CFR Part 268 in separate rulemaking under §3004(g)(4) and would develop corrective action requirements on a site-specific basis as part of the permitting process. With respect to the flexibility for minimum technology requirements (§3004(o) and §3005(j)), EPA solicits comments on how best to implement the flexibility provided by §3004(x), such as establishing requirements on a site-specific basis as part of the permitting process or development of revised standards under Subtitle C regulations.

The step-wise process that the Agency applied to the available information is outlined below.

Step 1. Does management of this waste pose human health/environmental problems? Might current practices cause problems in the future?

Critical to the Agency's decision-making process is whether each special waste either has caused or may cause human health or environmental damage. To resolve this issue, EPA has posed the following key questions:

1. Has the waste, as currently managed, caused documented human health impacts or environmental damage?
2. Does EPA's analysis indicate that the waste may pose a significant risk to human health or the environment at any of the sites that generate it (or in off-site use), under either current management practices or plausible mis-management scenarios?
3. Does the waste exhibit any of the characteristics of hazardous waste?

If the answer to any of these three questions was yes, then EPA concluded that further evaluation was necessary. If the answer to all of these questions was no, then the Agency tentatively concluded that regulation of the waste under RCRA Subtitle C is unwarranted.

Step 2. Is more stringent regulation necessary and desirable?

If the waste has caused or may potentially cause human health or environmental impacts under conservative risk assumptions, then EPA concluded that an examination of alternative regulatory controls was appropriate. Given the context and purpose of the present study, the Agency focused on an evaluation of the likelihood that such impacts might continue or arise in the absence of Subtitle C regulation, by posing the following three questions:

1. Are current practices adequate to limit contaminant release and associated risk?
2. What is the likelihood of new facilities opening in the future and generating and managing the special waste in a different environmental setting than those examined for this report?

3. Are current federal and state regulatory controls adequate to address the management of the waste?

If current practices or existing regulatory controls are adequate, and if the potential for actual future impacts is low (e.g., facilities in remote locations, low probability of new facilities being constructed, low likelihood of actual risk), then the Agency may tentatively conclude that regulation of the waste under Subtitle C is unwarranted. Otherwise, further examination of regulatory alternatives is necessary.

Step 3. What would be the operational and economic consequences of a decision to regulate a special waste under Subtitle C?

If, based upon the previous two steps, EPA believed that a waste might potentially be a candidate for regulation under Subtitle C, then the Agency estimated and evaluated the costs and impacts of two regulatory alternatives that are based upon Subtitle C, and one alternative that reflects one possible approach that might be taken under RCRA Subtitle D ("Subtitle D-Plus"). Two evaluations were performed. The first focused on the magnitude, distribution, and significance of the incremental costs of regulation under full Subtitle C as compared to the Subtitle D-Plus scenario for each potentially affected facility. The second focused on incremental costs and impacts associated with regulation under the Subtitle C-Minus scenario as compared to Subtitle D-Plus. The key questions in the Agency's decision-making process for both comparisons were as follows:

1. Are predicted economic impacts associated with the full Subtitle C (or Subtitle C-Minus in the case of the second comparison) scenario significant for any of the affected facilities?
2. Are these impacts substantially greater than those that would be experienced under the Subtitle D-Plus scenario?
3. What is the likely extent to which compliance costs could be passed through to product markets or input costs could be reduced, i.e., to what extent could regulatory cost burdens be shared?
4. In the event that costs are significant, could a large proportion of domestic capacity or product consumption be affected?
5. What effects would hazardous waste regulation have upon the viability of the beneficial use or recycling of the special waste?

In EPA's judgment, an ability to pass through costs or an absence of significant impacts suggested that Subtitle C regulation (or Subtitle C-Minus in the case of the second comparison) might be appropriate for wastes that pose significant risk. In cases in which the Subtitle C (or Subtitle C-Minus) scenario would impose widespread and significant impacts on facilities, result in reductions in domestic capacity or supply, and/or deter the safe and beneficial use of the waste, EPA tentatively concluded that regulation under some form of Subtitle D program might be more appropriate.

Step 4. Additional Considerations

In this fourth step, which EPA only included in one of the two decision-making approaches, EPA considered factors in addition to the §8002(p) study factors that relate to the broader goals and objectives of the Agency, including developing and maintaining strong state programs to regulate mining and mineral processing wastes. EPA believes that it may be appropriate to facilitate both development and maintenance of strong state programs and implementation of federal regulations for mineral processing wastes by regulating all special wastes from mineral processing under the mining wastes program being developed under Subtitle D of RCRA. The relevance of these additional factors, and their impact on EPA's findings, is discussed below.

4.0 Findings

Section 3001(b)(3)(C) of RCRA requires that the Agency determine, based on the findings of this report, and public hearings and comment, either to promulgate regulations under Subtitle C of RCRA for the wastes covered by this study or determine that such regulations are unwarranted. Accordingly, to facilitate comment on this report and the subsequent preparation by the Agency of the required "regulatory determination," this section presents EPA's findings regarding the 20 special wastes from mineral processing based on two separate approaches. These two approaches include:

- Application of the RCRA §8002(p) Study Factors, which discusses the regulatory approach (i.e., Subtitle D or Subtitle C) that the Agency tentatively concludes is appropriate for each of the 20 mineral processing wastes if the study factors listed in the statute alone are considered; and
- Application of the RCRA §8002(p) Study Factors and Additional Considerations, which discusses (1) additional factors that the Agency believes may be appropriate to consider in making a "regulatory determination" and (2) the tentative conclusions that may be drawn that include consideration of these additional factors.

EPA solicits comments on both of these approaches and the tentative conclusions presented below. With respect to the decision-making approaches, EPA solicits comments on: (1) what factors the Agency should consider in making the required regulatory determination; (2) what information should be used to evaluate these factors; and (3) the relative weight that the factors should be given in developing a regulatory determination.

4.1 Application of the RCRA §8002(p) Study Factors: Approach 1

As discussed above, RCRA §8002(p) specifies eight factors that the Agency shall include in the analysis performed for this report and suggests that EPA also examine federal and state agency programs to avoid duplication of effort. This section presents a summary of the Agency's analysis of these factors and the possible conclusions, pending receipt and analysis of public comments, that EPA might make regarding the appropriate regulatory status of the 20 mineral processing special wastes covered by this report. The 20 mineral processing special wastes are discussed in two groups: (1) wastes that the Agency might recommend regulating under Subtitle D of RCRA; and (2) wastes that the Agency might tentatively consider for regulation under Subtitles C or D.

Wastes EPA Might Tentatively Recommend to Remain Under RCRA Subtitle D

The available data, the analysis presented in this report, and consideration of the RCRA §8002(p) study factors suggest that regulation under Subtitle C of RCRA is unwarranted for the following 16 mineral processing wastes:

- Red and brown muds from bauxite refining;
- Treated residue from roasting/leaching of chrome ore;
- Gasifier ash from coal gasification;
- Process wastewater from coal gasification;
- Slag from primary copper processing;
- Slag tailings from primary copper processing;
- Slag from elemental phosphorus production;
- Iron blast furnace slag;
- Basic oxygen furnace and open hearth furnace slag from carbon steel production;

- Air pollution control dust/sludge from iron blast furnaces;
- Air pollution control dust/sludge from basic oxygen furnaces and open hearth furnaces from carbon steel production;
- Fluorogypsum from hydrofluoric acid production;
- Process wastewater from primary magnesium processing by the anhydrous process;
- Process wastewater from phosphoric acid production;
- Phosphogypsum from phosphoric acid production; and
- Slag from primary zinc processing.

In using the study factors listed in RCRA §8002(p), EPA used the approach described above in Section 3 to examine: (1) the potential for and documented danger to human health and the environment; (2) the need for additional regulations; and (3) the costs and impacts of Subtitle C regulation.

EPA did not find significant actual or potential danger associated with the following three wastes, based on waste characteristics, management practices, and damage case investigations:

- Treated residue from roasting/leaching of chrome ore;
- Process wastewater from coal gasification; and
- Slag tailings from primary copper processing.

None of these wastes exhibit a characteristic of hazardous waste and no documented damages were identified as associated with their management.

The other thirteen wastes listed above were identified as having some actual or potential hazard associated with current management practices or plausible mismanagement scenarios, and so were subsequently evaluated in the second stage of the process.

In the second stage of the evaluation, EPA identified four wastes that did not exhibit a hazardous characteristic (with the exception of one sample of copper slag at one facility) but for which documented cases of adverse environmental impacts that affected surface water were identified at at least one facility:

- Iron blast furnace slag;
- Slag from primary copper processing;
- Basic oxygen furnace and open hearth furnace slag from carbon steel production; and
- Fluorogypsum from hydrofluoric acid production.

In all four cases, however, these surface water releases (one of which occurred via ground water) have been and/or are being addressed under existing regulatory authorities at the state and/or federal level. In addition, the potential for risks associated with management of these wastes at potential new facilities is not likely to be greater than at the existing facilities. In the case of fluorogypsum, however, the available data indicate that the radionuclide content of the waste is such that under some circumstances (e.g., use of the wastes in construction) the waste may pose some radiation risk. As a result, EPA plans to investigate further the potential for exposure and associated radiation risk for fluorogypsum and, if appropriate, take steps to limit such risks under authorities provided by RCRA and other statutes.

EPA found that two wastes exhibited one or more of the hazardous characteristics, slag from primary zinc processing and process wastewater from primary magnesium processing by the anhydrous process. However, each is generated by a single facility, neither of which have documented damages after about 50 and 20 years of operation, respectively. In both cases, market conditions and production processes are such that construction of additional facilities in the foreseeable future is unlikely. In addition, state regulations are in effect for the one primary magnesium facility and being revised/strengthened for the primary zinc processing facility. EPA plans to investigate further off-site uses of zinc slag for uses that constitute disposal.

In addition, EPA found that the available data indicate that air pollution control (APC) dust/sludge from iron blast furnaces and from basic oxygen and open hearth furnaces used to make carbon steel exhibit the characteristic of EP toxicity at some facilities. For both types of dust and sludge, relatively few of the samples and facilities tested yielded EP-toxic results (for at most two constituents) and the magnitude of the exceedances was generally low. No damage cases were identified for either type of dust/sludge, either for on-site or off-site management. In addition, several facilities recycle rather than dispose the dust, the facilities are generally not in high risk settings, and construction of new facilities is not likely.

EPA also found that the potential for hazard associated with two other wastes, red and brown muds from bauxite refining and gasifier ash from coal gasification, was comparatively low, except for the radionuclide content of the wastes; in addition, no documented damages attributable to these two wastes were identified.[6] For both of these wastes, however, available data indicate that under some circumstances (e.g., use of the wastes in home building materials) the wastes may pose some radiation risk. As a result, EPA plans to investigate further the potential for exposure and associated radiation risk associated with use of these two mineral processing special wastes and, if appropriate, take steps to limit such risks under authorities provided by statutes other than RCRA.

The radionuclide content, and the associated potential for radiation risk, is also of concern in three other wastes: slag from elemental phosphorus production, and phosphogypsum and process wastewater from phosphoric acid production. With respect to slag from elemental phosphorus production, EPA found that average life-time cancer risks range from $4x10^{-4}$ to $1x10^{-3}$ in Soda Springs and Pocatello, Idaho as a result of the use of the slag in a wide range of construction applications. In other respects, the potential and documented danger associated with non-radioactive contaminants contained in elemental phosphorus slag appears to be relatively low because: (1) the slag does not exhibit any of the characteristics of hazardous waste; and (2) there are no documented damage cases.[7] In addition, construction of additional facilities in the foreseeable future appears unlikely. EPA plans to use the authority of RCRA §3001(b)(3)(B)(iii) to ban the use of this material in construction and/or land reclamation when the Agency issues its regulatory determination for mineral processing wastes. EPA is soliciting comments on the appropriate regulatory language that should be used and how such a ban should be implemented.

In the case of phosphogypsum, radionuclide hazards associated with air releases from gypsum stacks and off-site uses of phosphogypsum are being addressed by the Agency under 40 CFR, Part 61, Subpart R, National Emission Standards for Hazardous Air Pollutants (NESHAP), Radon Emissions from Phosphogypsum Stacks (54 FR 51654, December 15, 1989; 55 FR 13480, April 10, 1990; 55 FR 13482, April 10, 1990).

Phosphogypsum and phosphoric acid process wastewater are also of concern because damage case information indicates that both closed and currently active phosphogypsum stacks (in which both the phosphogypsum and the wastewater are managed) and wastewater cooling ponds have caused and/or are causing ground-water contamination at many facilities. In addition, available data indicate that phosphogypsum tested EP toxic at one of ten facilities, and process wastewater exhibits the characteristic of corrosivity at most facilities and the EP-toxicity characteristic at some facilities. Current regulations are apparently not adequate to prevent contamination (although this situation may change as state regulatory programs improve), so the potential costs of regulation under Subtitle C were examined in the third stage of the evaluation. EPA estimated that the incremental annualized cost of either full Subtitle C regulation or the Subtitle C-Minus scenario for phosphogypsum and process wastewater, as compared to the Subtitle D-Plus scenario developed for cost estimating purposes, could exceed $500 million and $50 million respectively, and could significantly affect several facilities. At facilities that EPA estimates could be significantly affected by costs associated with the Subtitle C or Subtitle C-Minus scenarios, the estimated costs of the Subtitle D-Plus scenario, expressed as a percent of the value of shipments, are substantially less at seven facilities. The estimated impacts associated with Subtitle C or C-Minus regulation at these facilities would be expected to be significant, and it is unlikely that these facilities could pass along their higher costs. EPA considered the combined costs of Subtitle C requirements for phosphogypsum and process wastewater because: (1) these two wastes are typically co-managed; and (2) the compliance costs associated with both wastes would apply to each facility. EPA is aware, however, that only a portion of the total process wastewater flow is typically co-managed with the phosphogypsum. The Agency may investigate the feasibility of separate management of these wastes, as well as separating various wastewater streams in the context of this decisionmaking and the development of the mining waste program under Subtitle D.

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[6] Ground-water contamination at the Dakota Gasification facility in North Dakota was identified, but the source of the contamination appears to be wastes other than the gasifier ash.

[7] Ground-water contamination has been identified at one site, but it appears that wastewater was the source rather than slag.

In any case, however, EPA is concerned that under some circumstances process wastewater from phosphoric acid may pose some radiation risk that would not be addressed by the NESHAP regulation noted above. As a result, EPA plans to investigate further the potential for exposure and associated radiation risk associated with this waste and, if appropriate, take steps to limit such risks under authorities provided by RCRA and other statutes.

Wastes EPA Might Tentatively Consider for Regulation Under RCRA Subtitles C or D

For the remaining four wastes (calcium sulfate wastewater treatment plant sludge from primary copper processing, slag from primary lead processing, process wastewater from hydrofluoric acid production, and chloride process waste solids from titanium tetrachloride production), EPA proceeded to evaluate the estimated incremental compliance costs and associated impacts in Step 3 of the analysis in two ways. First, EPA examined the estimated costs of regulation under Subtitle D (using the "D-Plus" scenario) relative to the estimated costs of full Subtitle C regulation (Approach 1A). Second, EPA examined the estimated cost of Subtitle D-Plus regulation relative to the cost of regulation under a Subtitle C scenario that utilizes flexibility provided by RCRA §3004(x) (Approach 1B). These two analyses are discussed below along with the results of analysis Steps 1 and 2 for each of the wastes. As already indicated, the Subtitle C-Minus and Subtitle D-Plus scenarios are based on the Agency's preliminary assessment of how regulatory requirements might be tailored for mineral processing wastes. Because of this, the Agency is unsure whether the cost/impacts in these comparisons are fully appropriate and specifically requests comments on them. The fact that a hypothetical Subtitle D-Plus scenario was used for comparison does not mean that any or all of these wastes will necessarily be proposed for further regulation.

Comparison of Subtitle D-Plus and Full Subtitle C (Approach 1A)

In applying Steps 1 and 2 of the analysis process, EPA found that each of these four special wastes have posed or may pose a danger to health or the environment. Available data indicate that all four of the wastes exhibit one or more of the characteristics of hazardous wastes. All of the wastes except process wastewater from hydrofluoric acid production exhibit the characteristic of EP toxicity at at least one facility. Process wastewater from hydrofluoric acid production is corrosive at all facilities where it is generated. Documented damages associated with current lead slag management practices were identified and the potential for damages exists for the other wastes as well. Ground-water contamination that may in part be attributable to calcium sulfate sludge from primary copper processing and chloride process waste solids from titanium tetrachloride production was identified at at least one facility that generates one of these wastes.[8]

In addition, the Agency is not confident that current practices and regulations are adequate to prevent further danger to health or the environment from these four wastes. Specific reasons are as follows:

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[8] Attribution of the observed ground-water contamination at these sites was not possible due to co-management of the special wastes with other wastes, the close proximity of other waste management units, and/or a long history of production and waste management activities at the site.

- Current management practices for hydrofluoric acid process wastewater have not prevented release at one of the currently active facilities. There is a potential for development of additional domestic hydrofluoric acid production capacity, and the corresponding construction of new facilities. New facilities may be located in sensitive environmental settings given that the principal feedstock (acid-grade fluorspar) is generally imported and facility locations with ready access to water transportation are most likely.
- In the case of calcium sulfate wastewater treatment plant sludge from primary copper processing, applicable solid waste regulations are limited in states where it is currently generated and generation of this waste at additional facilities appears likely.[9] At least some of these additional facilities are in environmental settings that may have a greater potential for risk than the facilities where the waste is currently generated. Ground-water contamination at one facility may be due at least in part to disposal of the sludge.
- Current management practices contributing to documented damages associated with lead slag are not adequately addressed by current regulations.
- Chloride process waste solids from titanium tetrachloride production are generated by facilities in eight states, some of which have relatively few solid waste regulations that are applicable to the management of this waste. Construction of several new facilities is expected and these facilities may be located in sensitive environmental settings given that the principal feedstock is generally imported and facility locations with ready access to water transportation are most likely. In addition, EPA is concerned that under some circumstances, chloride process waste solids from titanium tetrachloride production may pose some radiation risk. As a result, EPA plans to investigate further the potential for exposure and associated radiation risk associated with this waste and, if appropriate, take steps to limit such risks under authorities provided by RCRA and other statutes.

To conduct Step 3 of the analysis process under Approach 1A, EPA estimated the cost of regulating each of these wastes under full Subtitle C requirements. The Agency then compared the costs for full Subtitle C regulation to the estimated costs that might result from regulation under Subtitle D requirements similar to those being developed for mining wastes ("Subtitle D-Plus"). For three of the four wastes (calcium sulfate wastewater treatment plant sludge from primary copper processing, slag from primary lead processing, and chloride process waste solids from titanium tetrachloride production), the estimated costs for full Subtitle C regulation would be significantly larger and the associated impacts would be more significant at nearly all facilities than the estimated costs of regulation under the Subtitle D-Plus scenario. Using this approach, EPA would tentatively conclude that regulation of these three wastes under Subtitle C is not warranted.

For process wastewater from hydrofluoric acid production, EPA found that the estimated compliance costs for regulation under full Subtitle C and regulation under the Subtitle D-Plus scenario were comparable and that the likely economic impacts were not expected to be significant. Using this approach to the cost analysis, EPA would tentatively conclude that process wastewater from hydrofluoric acid production may warrant regulation under Subtitle C.

Comparison of Subtitle D-Plus and Subtitle C-Minus (Approach 1B)

Under Approach 1B to conducting Step 3, EPA estimated the cost of managing these four wastes under a Subtitle C scenario that utilizes flexibility provided by RCRA §3004(x) (Subtitle C-Minus). The Agency then compared the costs for Subtitle C-Minus regulation (rather than full Subtitle C regulation, as in Approach 1A) to the estimated costs that might result from regulation under Subtitle D requirements similar to those being developed for mining wastes (Subtitle D-Plus). EPA found that the estimated costs for the Subtitle C-Minus and Subtitle D-Plus scenarios are similar for nearly all facilities.

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[9] Additional facilities where the calcium sulfate wastewater treatment sludge may be generated include both existing copper smelting/refining facilities that do not currently generate the waste and potential new smelting/refining facilities, including a facility on the Gulf Coast of Texas.

4.2 Application of the RCRA §8002(p) Study Factors and Additional Considerations: Approach 2

Section 8002(p) of RCRA and the decision in *Environmental Defense Fund v. EPA*, 852 F.2d 1309 (D.C. Cir. 1988) make it clear that the Agency may and should consider the specific factors of §8002(p)(1)-(8) in making its decision regarding the appropriate regulatory status of special wastes from mineral processing. In addition, the Agency believes that it may be appropriate to consider other factors relating to the broader goals and objectives of the Agency, such as developing and maintaining strong state mining and mineral processing waste regulatory programs and facilitating implementation of federal programs (see Step 4 of the discussion of the decision rationale in Section 3.3 above).

The analysis of the §8002(p) study factors presented above indicates that management of one, and perhaps as many as four, mineral processing special wastes may be appropriate for regulation under Subtitle C if only the study factors are considered, primarily because: (1) they have or could pose a significant risk to human health and the environment under current management practices or plausible mismanagement scenarios; and (2) the costs and impacts of regulation under full Subtitle C (for one waste) or Subtitle C-Minus (for three additional wastes) are estimated to be comparable to the costs associated with regulation under a Subtitle D-Plus program. In the case of process wastewater from hydrofluoric acid production, the estimated costs for the various scenarios are similar in large part because EPA has projected that requirements that would be protective of human health and the environment under Subtitle C-Minus, and under full Subtitle C as well, might be similar to those that may be required under a Subtitle D-Plus program. Because of the potential similarity between Subtitle C-Minus and Subtitle D-Plus requirements, as well as broader Agency objectives, EPA believes that it may be appropriate to include consideration of the additional factors of state program development for mining and mineral processing waste streams including federal program oversight, in order better to distinguish between these two regulatory scenarios.

Many states have recently or are currently expanding the scope and requirements of their regulatory programs as they apply to mineral processing wastes. For example, Florida has recently developed a policy that requires additional controls, such as liners, for new or expanded phosphogypsum stacks and is developing proposed regulations to update this policy and expand its scope to include phosphoric acid process wastewater. Missouri passed the Metallic Minerals Waste Management Act in 1989, and implementing regulations are being developed, which require permits, closure plans, maintenance plans, and provisions for financial assurance. Pennsylvania has proposed Residual Waste Regulations that, if promulgated, would require permits with provisions for liners, leachate collection systems, monitoring wells, and disposal of leachate for special wastes from iron and steel production and zinc slag (as well as other wastes). Similarly, Delaware, Ohio, and Tennessee have all recently developed revised solid waste regulations that will increase the stringency of requirements for management of special wastes. Some other states, such as Indiana and Kentucky, already have programs that specify management standards for mineral processing wastes.

In addition, some of these and many other states are currently working with EPA in the development of a regulatory program for mining wastes. This program is designed to be site-specific, risk based, and comprehensive. It also is being targeted to address the characteristics of mining wastes and site conditions at mining sites.

EPA believes that it may be appropriate to facilitate both development and maintenance of strong state programs and implementation of any federal regulations that may be necessary for mineral processing wastes by regulating all special wastes from mineral processing under Subtitle D of RCRA. Some mining and mineral processing wastes may be excluded from any further federal regulation under RCRA.

In light of these considerations, the results of Approach 2 indicate that it may be appropriate for the waste streams identified above for potential Subtitle C (full C or C-Minus) regulation not to be subject to hazardous waste management standards, but instead to be retained within the Mining Waste Exclusion for mineral processing wastes. If such a finding is appropriate, EPA believes that it would need to be conditioned on the premise that major steps be taken to take near term actions to control releases from the facilities producing these waste streams. Some corrective measures are already being taken under a variety of Agency authorities (i.e., RCRA, Superfund, CWA) and more can and will be undertaken. EPA believes that the states must act to address the most immediate problems posed by these wastes, as well as any of the other mineral processing special wastes that have been found in this report to pose significant actual or potential hazard to human health or the environment. To assist in this effort, EPA would provide technical and other resource support to the involved states to improve their programs. If near term actions did not result in adequate control of such wastes, EPA would then take action to reconsider its regulatory determination and could designate certain waste streams as Subtitle C hazardous wastes.

REPORT TO CONGRESS
ON
SPECIAL WASTES FROM MINERAL PROCESSING

Methods and Analyses

Chapter 1
Introduction

Section 3001(b)(3)(A)(ii) of the Resource Conservation and Recovery Act (RCRA) excludes "solid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under Subtitle C of RCRA, pending completion of a Report to Congress required by §8002(p) and a determination by the EPA Administrator either to promulgate regulations under Subtitle C or that such regulations are unwarranted (as required by §3001(b)(3)(C)). In 1985, EPA published the required Report to Congress on solid wastes from mineral extraction and beneficiation.[1] On July 3, 1986 (51 FR 24496), EPA published a determination that regulation of such wastes under Subtitle C of RCRA was not warranted.

This report has been prepared in response to the requirements of §3001(b)(3) and §8002(p) that EPA study solid waste from mineral processing operations that were included within the exemption -- referred to as special wastes -- and prepare a Report to Congress on the findings of the study. This introduction provides: (1) a description of the scope of the mineral processing waste exemption; and (2) an overview of the content and organization of this report.

1.1 The Scope of the Mineral Processing Waste Exemption

On October 21, 1976, Congress enacted the Resource Conservation and Recovery Act (RCRA) (Pub. L. 94-580). Section 3001 of RCRA mandated that the EPA Administrator "promulgate regulations identifying characteristics of hazardous waste, and listing particular hazardous wastes which shall be subject to the provisions of this subtitle." Section 3004 required the Administrator to promulgate standards applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities.

In response to these requirements, EPA proposed regulations for managing hazardous wastes under Subtitle C of RCRA on December 18, 1978 (43 FR 58946). In this regulatory proposal, EPA proposed to defer most of the RCRA Subtitle C requirements for six categories of wastes, which it termed "special wastes," until information could be gathered and assessed and the most appropriate regulatory approach determined. EPA identified mining wastes as one of six such "special wastes" that were generated in large volumes, were thought to pose less risk to human health and the environment than wastes regulated as hazardous wastes, and for which the proposed technical requirements implementing Subtitle C might not be appropriate.[2]

In 1979, Congress began work on reauthorization of RCRA. During the reauthorization process, Rep. Thomas Bevill (Alabama) offered an amendment (now frequently referred to as the Bevill Amendment) which, among other things, modified §3001 to temporarily exempt "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and uranium ore" (along with two other categories of waste) from Subtitle C regulation, pending completion of certain studies. On October 12, 1980, Congress enacted the Solid Waste Disposal Act Amendments of 1980 (Pub. L. 96-482), which added §3001(b)(3)(A)(i-iii) (the Bevill Amendment) to RCRA.[3] These amendments also added §8002(p), which required the Administrator to study the adverse effects on human health and the environment, if any, of wastes from the disposal and utilization of "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ores," and submit a Report to Congress on its findings. In addition, the 1980 amendments added §3001(b)(3)(C), which requires the Administrator to make a regulatory determination, within six months of the completion of the §8002(p) studies, whether to regulate the wastes under Subtitle C of RCRA.

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[1] U. S. Environmental Protection Agency, 1985. Report to Congress on Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale, EPA/530-SW-85-033, Washington, D.C.

[2] The other five proposed "special wastes" specifically identified in the 1978 proposed rule were cement kiln dust waste; utility waste; phosphate rock mining, beneficiation, and processing waste; uranium mining waste; and oil and gas drilling muds and oil production brines.

[3] The 1980 Amendments also contained §3001(b)(3)(B)(iii), which provides authority for EPA to regulate the use of solid waste from the extraction, beneficiation, and processing of phosphate rock or overburden from uranium mining in construction or land reclamation, so as to prevent radiation exposure which presents an unreasonable risk to human health.

In response to the 1980 RCRA amendments, on November 19, 1980, EPA published an interim final amendment to its hazardous waste regulations to reflect the provisions of the Bevill Amendment (45 FR 76618). The regulatory language incorporating the exclusion was identical to the statutory language, except EPA added the phrase "including coal." In the preamble to the amended regulation, however, EPA tentatively interpreted the exclusion to include "solid waste from the exploration, mining, milling, smelting, and refining of ores and minerals."

In 1985, EPA proposed to narrow the scope of the exclusion as it applied to mineral processing wastes (50 FR 40292, October 2, 1985), although EPA subsequently withdrew this proposal (51 FR 36233, October 9, 1986). The Agency's decision to withdraw its 1985 proposal was challenged in court (*Environmental Defense Fund v. EPA*, 852 F.2d 1316 (D. C. Cir. 1988), cert. denied 109 S. Ct. 1120 (1989) (*EDF v. EPA*)). In this case, the petitioners contended, and the Court of Appeals agreed, that EPA's interpretation of the scope of the Bevill amendment as it applies to mineral processing wastes was "impermissibly over-broad." In reaching this decision, the Court found that Congress intended the term "processing" in the Bevill amendment to include only those wastes from processing ores or minerals that met the "special waste" criteria -- that is, "high volume, low hazard" wastes. 852 F.2d at 1328-29.

Through a rulemaking process completed with the publication of a final rule on January 23, 1990 (55 FR 2322),[4] the Agency has established that the temporary exemption from Subtitle C requirements established by the Bevill Amendment for mineral processing wastes and, therefore, the scope of this report is limited to 20 mineral processing wastes generated by approximately 91 facilities located within 29 states, representing 12 mineral commodity sectors, as follows:

- Alumina -- red and brown muds from bauxite refining
- Chromium (Sodium chromate/dichromate) -- treated residue from roasting/leaching of chrome ore
- Coal gas
    - -- gasifier ash from coal gasification
    - -- process wastewater from coal gasification
- Copper
    - -- slag from primary processing
    - -- calcium sulfate wastewater treatment plant sludge from primary processing
    - -- slag tailings from primary processing
- Elemental phosphorus -- slag from primary production
- Ferrous Metals (iron and carbon steel)
    - -- iron blast furnace air pollution control dust/sludge
    - -- iron blast furnace slag
    - -- basic oxygen furnace and open hearth furnace air pollution control dust/sludge
    - -- basic oxygen furnace and open hearth furnace slag

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[4] This rulemaking process also included publication of a proposed rule on October 20, 1988 (53 FR 41288), a proposed rule on April 17, 1989 (54 FR 15316), a final rule on September 1, 1989 (54 FR 36592), and a proposed rule on September 25, 1989 (54 FR 39298).

- Hydrofluoric acid
    - -- fluorogypsum
    - -- process wastewater
- Lead -- slag from primary processing
- Magnesium -- process wastewater from primary magnesium processing by the anhydrous process
- Phosphoric acid
    - -- phosphogypsum
    - -- process wastewater
- Titanium tetrachloride -- chloride process waste solids
- Zinc -- slag from primary processing

All other solid wastes from the processing of ores and minerals were removed from the Mining Waste Exclusion as of the effective date of the January 23, 1990 final rule (July 23, 1990), and are subject to regulation as hazardous wastes if they exhibit one or more characteristics of hazardous waste.

A summary of the important events in the rulemaking process and of the criteria that have been developed by the Agency to identify the 20 special wastes from mineral processing operations that are the subject of this report is presented in Appendix A (in Volume III) to this document.

1.2 Contents and Organization

This report addresses the following eight study factors required by §8002(p) of RCRA for the 20 mineral processing wastes listed above:

1. The source and volumes of such materials generated per year;
2. Present disposal and utilization practices;
3. Potential danger to human health and the environment from the disposal and reuse of such materials;
4. Documented cases in which danger to human health or the environment has been proved;
5. Alternatives to current disposal methods;
6. The costs of such alternatives;
7. The impacts of these alternatives on the use of phosphate rock, uranium ore, and other natural resources; and
8. The current and potential utilization of such materials.

In addition, the report includes a review of applicable state and federal regulations so that decisions that derive from the report avoid duplication of existing requirements.

The report consists of three volumes, as follows:

Volume I: Summary and Findings

- This volume provides an overview of the methods used to conduct the study, the decision criteria used by EPA in reaching its tentative conclusions, and the Agency's preliminary findings with respect to each of the 20 mineral processing wastes that are within the scope of the study.

Volume II: Methods and Analyses

- Chapter 1, Introduction, summarizes the scope, contents, and organization of the report.
- Chapter 2, Methods and Information Sources, presents an overview of the data sources used to prepare this report and the methods used to interpret these data.
- Chapters 3 through 14, summarize the information and analysis performed with respect to the study factors for the 20 mineral processing wastes, organized by 12 commodity sectors, as follows:
  - Alumina
  - Chromium (sodium chromate and dichromate)
  - Coal gas
  - Copper
  - Elemental phosphorus
  - Ferrous metals (iron and carbon steel)
  - Hydrofluoric acid
  - Lead
  - Magnesium
  - Phosphoric acid
  - Titanium tetrachloride
  - Zinc

  Each of these 12 chapters has seven sections. The first section provides a brief overview of the industry, including the types of production processes used and the number and location of operating facilities. The second section summarizes information on waste characteristics, as well as waste generation and management practices (study factors 1 and 2), while the third section provides a discussion of potential for and documented cases of danger to human health or the environment (study factors 3 and 4). The fourth section summarizes applicable federal and state regulatory controls (as suggested by § 8002(p) of RCRA, independent of the eight study factors). The fifth section discusses alternative waste management practices and potential utilization (study factors 5 and 8), while the sixth section discusses costs and impacts of alternative practices (study factors 6 and 7). The seventh and final section of each chapter summarizes the findings of the study for each commodity sector and the special waste(s) generated therein.

Volume III: Appendices

- Appendices A - E present additional information on the history of the Mining Waste Exclusion for mineral processing wastes; significant EPA data collection activities; risk assessment methodology and assumptions; existing regulatory controls; and cost and economic impact assessment methodology, assumptions, and results.

Additional documentation regarding the methods, data sources, and assumptions used in preparing this report and the analyses contained herein may be found in the RCRA docket (docket number F-90-RMPA-FFFFF).

Chapter 2
Methods and Information Sources

In preparing this report, EPA has developed facility-specific data and analytical methods that reflect the complexity of the issues that are addressed herein. The facilities that generate the special study wastes vary considerably in the types of production operations and waste management techniques that they employ. Moreover, to examine in detail the broad array of study factors mandated by RCRA §8002(p), EPA had to develop approaches and methods that were sufficiently sophisticated to take into account the special nature of high volume mineral processing wastes. This chapter outlines the data sources and methods that the Agency employed to respond to the statutory study factors, beginning with a discussion of the major data collection initiatives that EPA's Office of Solid Waste conducted during 1989 and proceeding to a discussion of the approach that EPA employed to address the salient features and implications of mineral processing waste generation and management.

2.1 EPA Data Collection Activities

After a review of the issues surrounding the Mining Waste Exclusion for mineral processing wastes and its history, EPA's Office of Solid Waste conducted a number of data collection activities to supplement and update previous work. The focus of most of these efforts was site-specific. As a consequence, EPA has been able to compile detailed facility- and sector-specific information, which the Agency has used extensively to prepare this report as well as a series of rulemakings which, in combination, have clarified the boundaries of the Mining Waste Exclusion as it applies to mineral processing wastes (as discussed above). The major information-gathering initiatives are identified and discussed in the following paragraphs.

Public Comments

Over the course of the past several years, EPA has received a considerable volume of written comments addressing the scope of the Mining Waste Exclusion for mineral processing wastes. The Agency has reviewed these comments, and has utilized pertinent information to supplement its knowledge of waste generation and management, product markets, waste management alternatives, and other topics related to this report.

1989 National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF Survey)

In early 1989, EPA prepared and submitted a written questionnaire to the operators of approximately 200 facilities that the Agency believed generated one or more solid wastes that might qualify for the Mining Waste Exclusion. These facilities were identified from information in existing Agency files, statements made in public comments on related proposed rulemakings, and from data supplied by the U.S. Bureau of Mines (BOM). The questionnaire was designed to elicit information on waste generation and management at mineral processing facilities, as well as on the operational characteristics of the facilities. The majority of the questions included in the survey questionnaire addressed waste management, and were ordered so as to "track" the wastes of interest from the point of generation through the ultimate disposition of all residuals.

Facility operator responses to the questionnaire provide nearly complete coverage of the facilities that currently generate one of more of the 20 special study wastes. Coverage for many of the 20 waste streams is complete, i.e., EPA has a census of all current generators of all but a few of these wastes. Responses to the questionnaire were encoded and entered into a computerized data base, which EPA has used in assembling the analyses described below. A description of the survey is presented in Appendix B-1 to this document.

Copies of the survey instrument, as well as any non-confidential individual company responses to the questionnaire, may be found in the supporting docket for this report.

1989 Mineral Processing Waste Sampling and Analysis

Because many of the wastes considered in this report had not been studied by OSW previously, and because existing data for some of the other wastes is sparse, EPA conducted a waste sampling and analysis program during the summer of 1989. The Agency's field sampling teams visited 37 mineral processing facilities, recorded observations regarding operational practices, took photographs of waste management activities, and collected samples. In many cases, EPA took samples of candidate special mineral processing wastes on both an "as-generated" basis and on an "as-managed" basis. Analytical data derived from wastes as-generated were used extensively in support of the recent series of rulemakings addressing the scope of the Mining Waste Exclusion, while the as-managed data have been used as a primary source of waste characterization data in preparing this report. These data may be found in summarized form in the supporting docket for this report, while a description of EPA's 1989 waste sampling study is presented in Appendix B-2 to this report.

Damage Case Collection

To respond to the need to describe "documented cases in which danger to human, health or the environment has been proved," (referred to in this report as "damage cases") as directed by the RCRA statute, EPA conducted an exhaustive examination of the extent to which any of the wastes considered in this report have been implicated in environmental contamination incidents. This effort began by contacting appropriate staff people in all EPA regions and states in which one or more facilities that does or did generate one of the 20 special mineral processing wastes is located. Where telephone contacts indicated that relevant damage case information might exist at the regional or state level, the information was obtained through the mail or through visits with state/local officials having regulatory jurisdiction over mineral processing waste management.

In some cases, personnel also visited the sites being evaluated. While in the field, EPA representatives obtained copies of information that might be relevant to evaluating a particular damage case. The result of this effort is a compilation of information regarding the past and present management practices that have been applied to special mineral processing wastes, and the environmental or human health consequences of these practices. Damage case findings are summarized by mineral commodity sector in the chapters that follow; the individual sites that have been evaluated in detail are listed in Appendix B-3. More extensive discussions and supporting evidence are provided in a technical background document that may be found in the supporting docket for this report.

EPA Site Visits

In addition to the waste sampling and damage case collection efforts described above, staff visited a number of active mineral processing operations during 1989 and 1990 in order to enhance the Agency's general understanding of the processes whereby special mineral processing wastes are generated, and of the techniques by which they are and could be managed. In total, EPA headquarters staff have, during the past two years, been on site and have observed the production and waste management operations at several dozen facilities representing all twelve of the mineral commodity sectors addressed herein. The knowledge and insights gained during these visits have enabled the Agency to understand and critically evaluate the adequacy of current waste management practices, and to draw conclusions and make recommendations regarding the regulatory status of the special mineral processing wastes.

RCRA §3007 Waste Characteristics Data Request

In order to augment existing EPA waste characterization data and to allow affected facilities to have meaningful input into the Agency's evaluation of the physical and chemical characteristics of temporarily exempt mineral processing wastes, EPA issued a formal written request, under authority of RCRA §3007, to facility operators seeking any currently available information on the characteristics of the candidate special mineral processing wastes that they generate. The request did not specify the quantity of data required by EPA or a data format, so as to make compliance by the facility operators as simple as possible. An example of the §3007 data request is presented in Appendix B-4 to this report.

Facility operators responded in a number of different ways, up to and including submitting hundreds of pages of process control data. EPA has reviewed all of these data submittals and has collected and summarized all data that are both useable (e.g., identity of waste stream and analytical testing method is clear) and relevant to this study.

2.2 Analytical Approach and Methods

EPA has consolidated its analysis of certain of the eight study factors identified in Chapter 1, so as to facilitate focused analysis and clear exposition of the information that is germane to the decisions at hand, i.e., whether Subtitle C regulation of any of the 20 special mineral processing wastes is appropriate. The Agency has employed this approach because several of the study factors overlap or are closely related to one another. Consequently, the sector-specific chapters that follow consist of an introduction, five substantive sections addressing the study factors, and a summary section.

The remainder of this chapter summarizes EPA's approach for addressing each of the required study factors. The sections that follow present the methods that the Agency has employed in preparing the six substantive parts of each sector-specific chapter:

- Section 2.2.1, Waste Generation, Characteristics, and Current Management Practices, describes the identification of facilities that generate one or more of the special study wastes, development of descriptions of production processes, product uses, general waste composition, and waste generation and management practices (study factors 1 and 2), as well as the relationship of this information to analysis of the remaining study factors.
- Section 2.2.2, Potential and Documented Danger to Human Health and the Environment, presents the approach that EPA used to assess the potential danger posed by each of the 20 wastes under study and identify proven cases of danger to human health and the environment (study factors 3 and 4).
- Section 2.2.3, Existing Federal and State Waste Management Controls, describes the Agency's approach to developing an improved understanding of current federal and state requirements that apply to special mineral processing wastes (as suggested by §8002(p) of RCRA, independent of the eight study factors).
- Section 2.2.4, Alternative Management Practices and Potential Utilization, discusses the identification and evaluation of alternatives to current waste management and utilization practices (study factors 5 and 8).
- Section 2.2.5, Cost and Economic Impacts, presents the Agency's approach to specifying alternative regulatory scenarios and estimating the associated costs and economic impacts (study factors 6 and 7).
- Section 2.2.6, Summary, provides a description of the way in which EPA has evaluated the study factors, in order to facilitate future regulatory decision-making.

2.2.1 Waste Characteristics, Generation, and Current Management Practices

To characterize the generation and management of each of the 20 special mineral processing wastes, EPA needed to identify the facilities that generate the wastes, the production processes used and the products produced, the quantity and characteristics of the wastes generated, and the practices that are employed to manage them. EPA's approach to addressing each of these needs is described below, followed by a discussion of the relationship of the resulting information to the other study factors.

Affected Facilities

The identification of the facilities that generate one or more of the twenty special wastes was begun during the reinterpretation of the Mining Waste Exclusion for mineral processing wastes. This rulemaking process began in August, 1988 and continued through the publication of a final rule in January 1990. Beginning with previous EPA studies and additional published sources (e.g., SRI International's Directory of Chemical Producers--United States, 1989 Ed.), and relying extensively on support from Commodity Specialists with the U.S. Bureau of Mines, the Agency established a list of facilities that were believed to produce a mineral commodity of interest and potentially generate a special waste. The operators of these facilities were sent a survey requesting information on waste generation and management. A brief discussion of the survey is provided above in Section 2.1. Survey responses allowed EPA to finalize its list of the active facilities in the mineral processing sectors of concern. Production data (e.g., quantity of the primary commodity produced, the age and capacity of the operation) were also obtained from these surveys.

Process Descriptions and Product Use(s)

Process descriptions were developed to characterize the major type(s) of process operations employed in each sector. Detailed discussion of waste generation from these processes within this report is limited to the special waste(s) within each commodity (i.e., one of the twenty waste streams studied in this report) and does not involve other wastes or secondary materials that may be generated.

Information regarding production processes was taken primarily from the Encyclopedia of Chemical Technology edited by Marks, et al., and published in 1978. This source, however, provides little or no information regarding the point-of-generation of the waste streams in question. Relevant point-of-generation data were obtained from public comments submitted by the industry, previous EPA reports (e.g., Overviews of Solid Waste Generation, Management, and Chemical Characteristics for various processing sectors prepared for EPA by PEI Associates and Radian Corporation), and Bureau of Mines publications (e.g., Mineral Facts and Problems, 1985 Ed.).

Information describing the use of mineral products was taken primarily from Bureau of Mines publications (i.e., Mineral Facts and Problems, 1985 Ed., Mineral Commodity Summaries, 1989 Ed., and Minerals Yearbook, 1987 Ed.). Additional information was obtained from public comments and trade publications.

EPA's understanding of mineral production processes and product uses has also been significantly enriched as a result of the field sampling and site visits described above. In a number of instances, subtle differences between facilities in a given commodity sector with respect to the production processes employed and product types produced (hence, markets served) have been noted. The knowledge gained thereby has been incorporated into the Agency's analyses and throughout the sector-specific discussions that follow this chapter, as appropriate.

Waste Generation and Management

In order to describe each facility's waste generation and to prepare the analyses of risk and cost and economic impacts, and potential for alternative utilization, the Agency needed to accurately assess the volume of waste generated at each facility. In estimating waste generation rates for the twenty waste streams, EPA primarily used data from its 1989 National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF Survey), and information supplied by industry experts at the U.S. Bureau of Mines. In some cases, EPA utilized data submitted in public comments by facility operators and trade associations.

EPA also compiled and tabulated facility-specific data on the general physical characteristics and chemical composition of the twenty wastes, and on the practices employed to manage them, again based primarily on the SWMPF Survey data, and has used these data in subsequent analyses. Such data also came from EPA sampling activities, site visits, and other data collection requests (e.g., RCRA §3007 requests, damage case data collection). Facility-specific details regarding waste management include type(s) of management units and volumes managed in each unit, pollution controls in place for each unit (e.g., liner type and number, presence of leachate collection systems, run-on/run-off and wind dispersal controls), and whether or not ground water, surface water, and/or air is currently monitored. EPA also collected and evaluated information on waste treatment, including types of reagents used and management techniques applied to treatment sludges and effluent(s).

Information submitted by industry in response to the SWMPF Survey was supplemented and critically evaluated against data obtained from published sources, information collected as part of the damage case development process, and EPA observations made during waste sampling and other site visits. The descriptions of waste management practices provided in this report reflect EPA's synthesis of the information obtained during all of these information collection activities.

Relationship of Waste Generation and Management Practice Information to other Parts of the Report

Waste characteristics, generation, and management data have been collected and analyzed for two primary purposes: 1) to understand the industry (i.e. RCRA §8002(p)(1-2) require EPA to analyze "the source and volumes of such materials generated per year; (and) the present disposal and utilization practices"), and 2) to evaluate risk, alternative management practices (including utilization), and costs and impacts of such alternative management practices (RCRA §8002(p)(3) and (5-6)).

Risk Assessment

Waste generation rates, physical and chemical characteristics, and management practices are three major inputs to the analysis of the risk posed to human health and the environment by the wastes under study in this report. The quantity of waste managed is important in evaluating the magnitude and duration of environmental impacts. Waste characteristics, in part, determine whether the waste has the potential to release harmful constituents to the environment. Knowledge of waste management practices, including controls (e.g., caps, liners) for the protection of the various media of environmental transport (e.g., air, surface water, ground water) will, in part, determine the ability of any harmful constituents to be transported to potential human or biotic receptors.

Evaluation of Management Alternatives and Potential Utilization

Waste characteristics and the outcome of the risk and damage case analyses determine the need for and types of alternative management practices that EPA might consider. In addition, the technical feasibility of management alternatives and the economic feasibility of utilization alternatives are directly affected by waste generation rates.

Cost and Economic Impacts

The volume and management practice data are key inputs into the evaluation of the costs of both existing and alternative waste management practices. Cost estimation equations are driven primarily by the volume of the waste managed and include a logarithmic component to simulate the effects of economies of scale. Alternative waste management practices involve compliance with additional design specifications that must be modeled by the cost estimation procedure. Waste characteristics are important in that they are a factor in determining what type of management alternatives may be required for the protection of human health and the environment.

2.2.2 Potential and Documented Danger to Human Health and the Environment

Potential Danger to Human Health and the Environment

EPA conducted a facility-specific analysis of the risks associated with each of the 20 mineral processing wastes. The Agency collected information on the major factors that influence risks from the management of the special wastes at each of the 91 facilities that generate the wastes, and analyzed this information to develop conclusions on the potential for toxic constituents to be released from the waste and cause human health and environmental impacts.

EPA used a three step approach in this risk assessment, as illustrated in Exhibit 2-1:

- First, the Agency assessed the intrinsic hazard of the wastes by comparing the concentrations of toxic or radioactive constituents in the wastes and in the leachate extracts from the wastes to screening criteria.[1] This step was used to determine which constituents of the special wastes do not pose a risk to human health or the environment, even under very conservative (i.e., protective) release and exposure assumptions. If a waste contained constituents in concentrations that exceeded the screening criteria, then the Agency further evaluated (in the next step of the analysis) the potential for the waste to pose risk. A detailed discussion of the screening criteria and their derivation is provided later in this chapter and in Appendix C-1 to this report.
- Second, EPA assessed the potential for constituents of potential concern from the wastes to cause damage at the 91 facilities that generate the special wastes by evaluating the practices currently used to manage the wastes and the environmental settings in which the wastes are managed. Using facility-specific information about special waste management and environmental setting, EPA evaluated the potential for toxic or radioactive constituents that exceed the screening criteria to be released from waste management units and to migrate to potential exposure points.
- Third, EPA performed quantitative modeling to estimate the human health and environmental risks associated with existing waste management practices. In this portion of the analysis, EPA estimated risks for only those wastes, facilities, and potential release and exposure pathways that appeared to pose a hazard based on the findings from the previous steps of the risk assessment.

The Agency used each step as a means of narrowing the scope of the analysis to those wastes and facilities that pose the greatest potential risk. The evaluation of the intrinsic hazards of the wastes (Step 1) was used to eliminate from further consideration any toxic or radioactive constituents that are not present in concentrations of concern (based on conservative exposure assumptions). Evaluation of release, transport, and exposure potential (Step 2) was used to identify potential exposure pathways and to allow a categorization of the risk potential (i.e., high, medium, low) for all facilities generating each waste. Risk modeling (Step 3)

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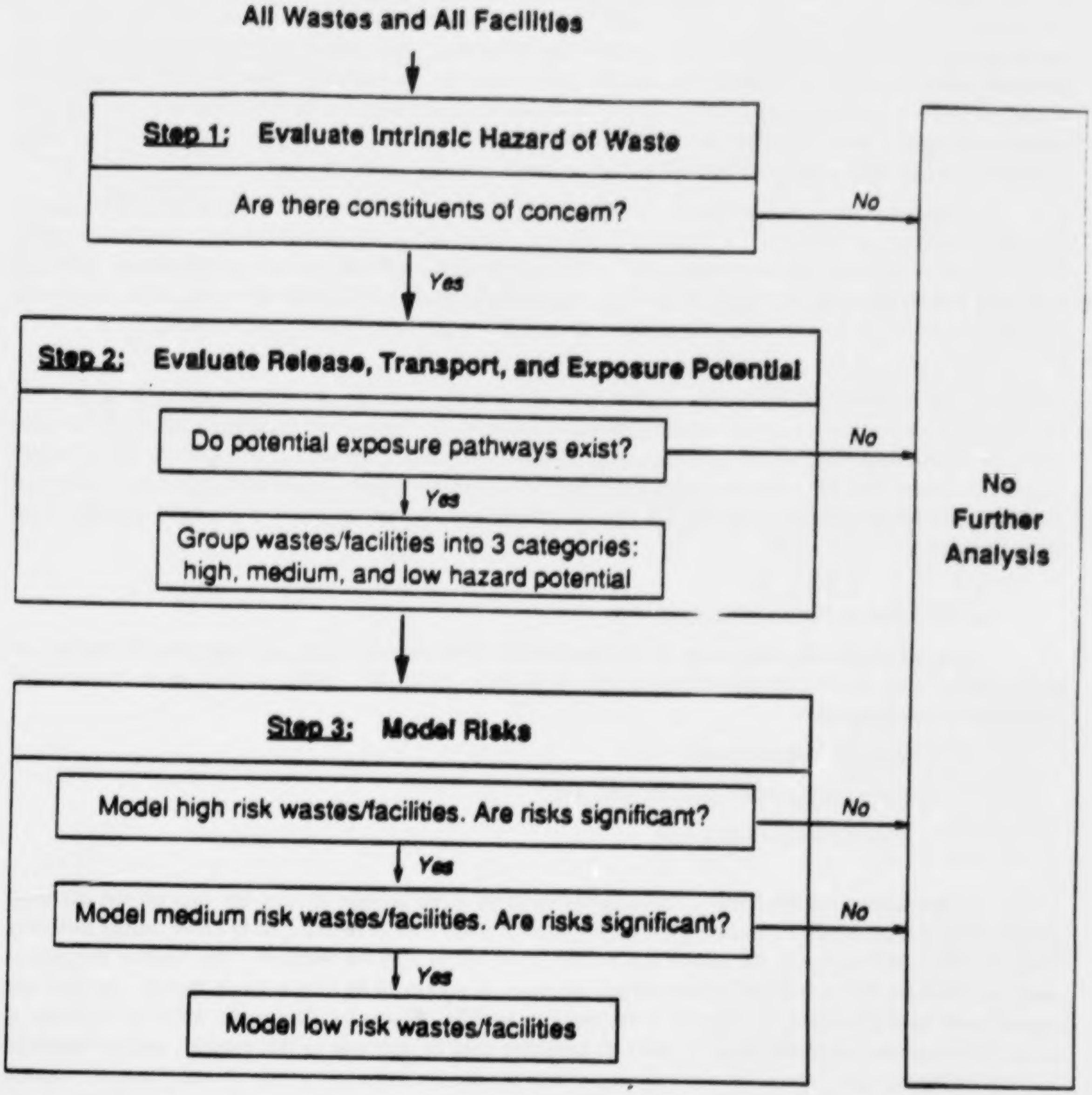
[1] The focus of the screening criteria is on toxicity and radioactivity, in addition to a simple determination of corrosivity. EPA has sufficient knowledge of the characteristics of the 20 special mineral processing wastes to conclude that none are ignitable or reactive.

Exhibit 2-1
Overview of Risk Assessment Methodology


All Wastes and All Facilities
Step 1: Evaluate Intrinsic Hazard of Waste
Are there constituents of concern?
No
Yes
Step 2: Evaluate Release, Transport, and Exposure Potential
Do potential exposure pathways exist?
No
Yes
Group wastes/facilities into 3 categories: high, medium, and low hazard potential
Step 3: Model Risks
Model high risk wastes/facilities. Are risks significant?
No
Yes
Model medium risk wastes/facilities. Are risks significant?
No
Yes
Model low risk wastes/facilities
No Further Analysis

was limited initially to facilities with the highest risk potential. Modeling of additional facilities was performed only if estimated risks were significant for the facilities with high risk potential.

In all steps of the analysis, EPA focused on human health and environmental risks associated with chronic exposures to potential releases of waste constituents to ground water, surface water, and air. While large, short-term (acute) exposures to these wastes may occur, this analysis is restricted to chronic exposures, for two reasons. First, given the relatively low hazard of these wastes (as documented by application of the low hazard criterion used in the Agency's recent rulemakings on these special wastes), EPA concluded that the potential for adverse effects from large, short-term exposures to these wastes is very limited (i.e., acute risk generally occurs at levels of exposure that are not likely given the low hazard of these wastes). Second, most of the toxicological data and exposure assumptions available for the purpose of risk assessment are based on chronic exposures. When possible, the Agency did evaluate the potential for large episodic releases of waste constituents (e.g., from storm or flood events) to endanger human health or the environment.

To analyze risks to human health, the Agency evaluated the cancer and non-cancer risks to maximally exposed individuals at each site. A "maximally exposed individual" is designated for each exposure pathway as the person at greatest risk from exposures to toxic constituents released into the environment. EPA did not assess population risks explicitly, but data on potentially exposed populations were considered in drawing conclusions about the overall risks associated with the current management of special wastes.

To analyze environmental risks, the Agency evaluated the potential for contaminants to migrate from the waste and adversely affect aquatic organisms. EPA did not attempt to evaluate potential impacts on terrestrial ecosystems because little information is available on the exposure of terrestrial organisms to waste constituents and toxicological data relevant to terrestrial ecosystems are limited. In addition to risks to human health and aquatic life, EPA also evaluated the potential for existing waste management practices to cause air and water contamination, irrespective of the potential for humans or ecological receptors to be exposed to the contamination.

Data Used in the Risk Assessment

To conduct the risk assessment as outlined above, EPA collected and evaluated data on the factors that influence risks at each facility that generates the wastes. EPA's data collection focused on three major categories of information:

- waste composition data,
- waste management practice data, and
- environmental setting data.

Waste Composition Data. The Agency relied on three primary sources for data on the chemical composition of each mineral processing waste. First, the Agency used data collected by OSW during sampling visits in 1989. OSW sampled the wastes at a total of 27 of the 91 affected facilities. The Agency sampled at least two facilities for each waste stream unless the waste is generated by only a single facility. Second, the Agency used data submitted by industry in response to an EPA request for data under §3007 of RCRA. A total of 64 facilities submitted useable waste composition data in response to this request, and all wastes of interest are represented in these data except magnesium process wastewater and treated roast/leach ore residue from sodium dichromate production. Third, EPA used waste composition data collected by ORD during sampling visits in 1984 and 1986, and data collected by OSW during sampling visits in 1985. Data collected by ORD are available for five wastes studied in this report: lead slag, copper slag, phosphoric acid process wastewater, phosphogypsum, and elemental phosphorus slag. Data collected by OSW in 1985 are for red and brown muds from alumina production. All together, these three sources provide data on the concentration of some 20 metals, 3 radionuclides, gross alpha and beta radiation, and a number of other constituents (including several ions and, in the case of the coal gasification wastes, numerous organic compounds). A more detailed discussion on the amount and nature of data considered for each special waste is provided in the sector-specific chapters of this report.

Although data on waste composition were provided in responses to the 1989 National Survey of Solid Wastes from Mineral Processing Facilities, the Agency did not use these data in the risk assessment for two reasons. First, the survey responses often provide information on only the primary components of the waste and do not characterize the waste's trace constituents, which are often important from a risk assessment standpoint. Second, the survey responses provide only single, "typical" concentrations and do not indicate the number of samples upon which those typical values are based, the time frame over which the samples were collected, the sampling locations, or the distribution of individual sample results. As a result, the typical concentrations reported in the survey could not be integrated with sampling data from the other sources outlined above to develop overall statistics on the frequency and magnitude with which constituent concentrations exceed the screening criteria.

Waste Management Practice Data. For data on current waste management practices, EPA relied primarily on information provided in response to the 1989 National Survey of Solid Wastes from Mineral Processing Facilities and information collected from visits to a number of the facilities studied for this report. The survey responses, prepared by facility personnel, include information on the waste volumes generated and managed at each plant, the quantity of waste managed in individual units, and the design characteristics of each management unit. Reports from visits to mineral processing facilities for sampling or other information collection purposes were used to supplement the data provided in the survey responses. These reports contain additional information on the design of waste management units as well as observations about the physical form of the wastes and photographs of the waste management units.

Environmental Setting Data. EPA relied on a number of sources of data on the environmental setting of the 91 facilities that generate the special wastes covered by this study. The environmental setting data collected for the risk assessment include information on climatological conditions, factors affecting atmospheric dispersion, hydrogeological parameters, surface water characteristics, population distributions, and proximity to sensitive environments (i.e., environments that are vulnerable or have a high resource value, such as National Parks or Forests). These data were collected from a number of sources, including EPA data compilations (e.g., Graphical Exposure Modeling System [GEMS] and Federal Reporting Data System [FRDS]); responses to the 1989 National Survey of Solid Wastes from Mineral Processing Facilities; U.S. Geological Survey (USGS) topographic maps and hydrologic data files; the National Water Well Association's DRASTIC ground-water vulnerability system; soil surveys developed by the Soil Conservation Service of the U.S. Department of Agriculture, and U.S. Department of the Interior (DOI) maps of the critical habitat of endangered species (50 CFR 17.95).

Evaluation of Intrinsic Hazard of Wastes

As the first step of its risk assessment, EPA screened the waste composition data described above to determine if the special wastes contain toxic or radioactive constituents at concentrations that could pose risks to human health, aquatic organisms, and air and water resource quality. The objective of this screening procedure was twofold: (1) to narrow the focus of the risk assessment by eliminating from further evaluation those constituents that are unlikely to endanger human health or the environment; and (2) to identify any constituents that warrant further evaluation (i.e., constituents of potential concern). To determine constituents of potential concern, EPA compared the constituent concentrations measured in samples of mineral processing wastes to screening criteria, and evaluated the persistence and mobility of each constituent in various environmental media.

Comparison of Chemical Concentrations to Screening Criteria. EPA developed a set of constituent-specific screening criteria that reflect the potential for hazards to human health, aquatic organisms, and air and water quality based on conservative release, transport, and exposure assumptions. These screening criteria represent constituent concentrations in waste or leachate samples that could endanger human health, aquatic life, or water or air quality if the waste is released to the environment. Because this step is intended to evaluate the intrinsic hazard of the wastes, the screening criteria are based on exposure assumptions that are likely to overstate the risks posed by the management of the wastes at the facilities of concern. Consequently, this step identifies all constituents that warrant further evaluation as potential constituents of concern, and only those constituents that do not contribute to the intrinsic hazard of the waste are removed from further consideration. The underlying rationale for the screening criteria developed for this analysis is summarized in Exhibit 2-2, and the actual screening values are listed in Exhibit 2-3 (the benchmarks upon which these screening criteria were developed are provided in Appendix C-1 of this report). All screening criteria developed for chromium assume that this metal is present in its more toxic hexavalent form.

As shown in Exhibits 2-2 and 2-3, the screening criteria can be divided into two main categories: (1) criteria to compare to constituent concentrations measured in solid samples, and (2) criteria to compare to constituent concentrations measured in liquid and leachate extract samples, or in extract samples from solids. The screening criteria compared to concentrations in solid samples include criteria that reflect the potential for hazards to human health via inhalation, incidental soil ingestion, and multiple radiation exposure pathways, as well as a criterion that reflects the potential for air quality degradation.

- Human Health/Inhalation Screening Criteria. To develop these criteria, the Agency used inhalation cancer slope factors from EPA's Integrated Risk Information System (IRIS) to derive an airborne concentration of carcinogens that corresponds to a lifetime cancer risk of 1×10^{-5}. Similarly, the Agency used inhalation reference doses from IRIS for non-carcinogens to derive an airborne concentration that, if inhaled, would result in the reference dose. To convert these airborne concentrations (in units of ug/m^3) to solid concentrations (in units of ug/g) the Agency made two conservative (i.e., protective) assumptions: (1) the airborne concentration of respirable particles equals the National Ambient Air Quality Standard (NAAQS) for respirable particulate matter (50 ug/m^3), and (2) the constituent concentration in the airborne respirable particles equals the constituent concentration in the waste. These assumptions probably overestimate the extent to which respirable particles are blown into the air from the special wastes studied in this report because many of the wastes are in the form of large particles (ranging in size all the way up to boulders) or form surface crusts that are not susceptible to dust generation.

- Human Health/Soil Ingestion Screening Criteria. To develop these screening criteria, EPA used oral cancer slope factors and non-cancer reference doses from IRIS, along with an Agency guideline on soil ingestion rates,[2] to derive a waste concentration that could cause health risks if small quantities of the waste are incidentally ingested on a routine basis. These screening criteria are based on the assumption that public access to the wastes is not restricted and, for example, children are allowed to play on, or in the vicinity of, special waste management units.

- Human Health/Radiation Exposure Screening Criteria. To screen for potential radiation hazards, the Agency used EPA's standard in 40 CFR 192 for the clean up of soil contaminated with radium-226 at uranium mill tailings sites (5 pCi/g). This standard is designed to limit the risk from the inhalation of radon decay products in houses built on contaminated land and to limit gamma radiation exposures of people using contaminated land. The Agency also used the Nuclear Regulatory Commission's (NRC's) guidelines for acceptable concentrations of uranium-238 and thorium-232 in soil that can be released for unrestricted use.[3] As stated in these standards and

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[2] Memorandum from J. Winston Porter, Assistant Administrator for EPA's Office of Solid Waste and Emergency Response, to EPA Regional Administrators, concerning Interim Final Guidance for Soil Ingestion Rates, OSWER Directive 9850.4, January 27, 1989.

[3] NRC, 1981. Disposal or Onsite Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present) from Past Operations, SECY 81-576, October 5.

Exhibit 2-2
Overview of Constituents of Concern Screening Criteria

Sample Test Type	Type of Hazard That Is Evaluated	Assumed Release/ Exposure Pathway That Underlies Screening Criteria	Screening Criteria
Solid Samples	Human Health Risk	Inhalation of airborne particulates	Inhalation toxicity criteria for cancer and noncancer effects, assuming that dust is blown into the air in a concentration that equals the National Ambient Air Quality Standard (NAAQS) for particulate matter
		Incidental ingestion of waste and contaminated soil	Oral toxicity criteria for cancer and noncancer effects, assuming that access to a waste is not restricted and children incidentally ingest contaminated solids
		Radiation exposure to contaminated land	EPA's radium-226 cleanup standard for uranium mill tailings sites: Nuclear Regulatory Commission guidelines on uranium-238 and thorium-232 concentrations in soil that can be released for unrestricted use
	Air Quality Degradation	Airborne release of lead as windblown dust	Lead concentration in waste that could result in an exceedance of the NAAQS for lead if dust is blown into the air in a concentration that equals that NAAQS for particulate matter
Liquid Samples (including leachate test samples)	Human Health Risk	Ingestion of contaminated ground water	10 times oral toxicity criteria for cancer and noncancer effects, assuming ingestion of 2 liters of contaminated water per day for 70 years
	Aquatic Ecological Risk	Release of waste constituents to surface water and exposure of aquatic organisms	100 times Ambient Water Quality Criteria (AWQC)
	Surface and Ground-Water Quality Degradation	Release of waste constituents to surface or ground water	10 times drinking water maximum contaminant levels when available; otherwise, the lower of: (1) 10 times the taste and odor thresholds, livestock watering guidelines, or irrigation guidelines; or (2) 100 times the AWQC for fish ingestion

guidelines, the radiation criteria are based on the assumption that public access to the waste is unrestricted.

- Air Resource Damage Screening Criterion. To screen for the potential for mineral processing waste solids to degrade ambient air quality, EPA used the NAAQS for particulate matter and the NAAQS for lead to derive a lead concentration in solid waste (there are no NAAQSs for any other metals that could exist in mineral processing wastes). Exceedance of this screening criterion indicates the potential for an exceedance of the lead standard if a sufficient amount of a waste is blown into the air as dust.

The screening criteria used to evaluate constituent concentrations in liquid samples (either total liquid or leach test analyses) include criteria that reflect the potential for hazards to human health via water ingestion, adverse effects to aquatic organisms, and degradation of surface and ground-water quality. In developing these criteria, the Agency has assumed a 10-fold dilution of liquid wastes or leachate into ground water and a 100-fold dilution in surface water. The Agency selected these conservative (i.e., small) dilution factors because the screening criteria are designed to evaluate the intrinsic hazard of the wastes, irrespective

Exhibit 2-3
Screening Criteria Values[a]

Constituent	Screening Criteria for Solid Samples			Screening Criteria for Liquid/Leach Test Samples		
	Inhalation (μg/g)	Incidental Ingestion (μg/g)	Radiation (pCi/g)	Human Health (Ingestion) (μg/L)	Aquatic Ecological (μg/L)	Water Resource Damage (μg/L)
Acetonitrile	–	4,200	–	2,100	–	–
Aluminum	–[b]	–	–	–	8,700	50,000
Antimony	–	280	–	140	160,000	4,500,000
Arsenic	14	4	–	2	1,300	500
Barium	7,000	35,000	–	18,000	5,000,000	10,000
Beryllium	84	3,500	–	1,800	530	120
Boron	–	63,000	–	32,000	500,000	7,500
Cadmium	115	350	–	180	110	100
Chloride	–	–	–	–	23,000,000	2,500,000
Chromium(VI)	17	3,500	–	1,800	1,100	500
Cobalt	–	–	–	–	–	500
Copper	–	25,900	–	13,000	290	13,000
Fluoride	–	42,000	–	21,000	–	40,000
Gross alpha	–	–	–	–	–	150 pCi/L
Gross beta	–	–	–	–	–	500 pCi/L
Iron	–	–	–	–	100,000	3,000
Lead	30,000[c]	420	–	210	320	50
Magnesium	–	–	–	–	–[d]	–
Manganese	21,000	140,000	–	70,000	100,000	500
Mercury	–	210	–	100	1.2	20
Molybdenum	–	–	–	–	–	100
Nickel	833	14,000	–	7,000	830	2,000
Nitrate	–	700,000	–	350,000	9,000,000	100,000
Nitrite	–	70,000	–	35,000	6,000	10,000
pH	–	–	–	–	6.5-9	6.5-8-5
Phenol	–	420,000	–	210,000	256,000	1
Phosphorus	–	–	–	–	10	–
Phosphate (Total)	–	–	–	–	2,500	–
Radium-226	134 pCi/g	–	5	16 pCi/L	–	50 pCi/L
Selenium	80	2,100	–	1,100	500	100
Silver	–	2,100	–	1,100	12	500
Sulfate	–	–	–	–	–[d]	2,500,000
Suspended Solids	–	–	–	–	2,500,000	–
Thallium	–	49	–	25	4,000	4,600
Thorium-232	13 pCi/g	–	10	91 pCi/L	–	–
Uranium-238	17 pCi/g	–	10	15 pCi/L	–	–
Vanadium	–	4,900	–	2,500	128,000	1,000
Zinc	–	140,000	–	70,000	8,600	50,000

(a) See text for an explanation of the derivation of these screening criteria and Appendix C-1 of this report for a presentation of the benchmarks upon which these screening criteria are based. Some of these screening criteria, especially the incidental ingestion criteria, are very high values (e.g., the incidental ingestion criterion for nitrate is more concentrated than normal fertilizer). However, they were derived using the methods described in the text and represent concentrations that could be harmful under the assumed exposure scenarios.

(b) No screening criterion used because of lack of applicable benchmarks.

(c) No inhalation RfD for lead is provided in IRIS. This value is the screening criterion used to analyze the potential for "air quality degradation."

(d) An aquatic ecological screening criterion of 5,000,000 ug/L Total Dissolved Solids was used to evaluate the combined concentration of magnesium and sulfate.

of the settings in which they are currently managed. The factors of 10 and 100 for ground water and surface water, respectively, reflect a minimal level of dilution expected to occur as constituents are released to receiving waters in which exposures or resource damage could occur. Consequently, the resulting screening criteria eliminate from further evaluation only those constituents that are not expected to pose a risk, even in the event that waste contaminant concentrations are not extensively diluted before reaching exposure points.

- Human Health/Water Ingestion Screening Criteria. To develop these criteria, EPA used oral cancer slope factors from IRIS to derive a liquid concentration of carcinogens that corresponds to a cancer risk of 1×10^{-5}. Similarly, the Agency used oral reference doses from IRIS for non-carcinogens to derive a liquid concentration that, if ingested, would result in the reference dose. The Agency then multiplied these concentrations by a factor of 10 to derive a liquid waste or leachate concentration that accounts for possible dilution that may occur if the waste is released to ground water.

- Aquatic Ecological Risk Screening Criteria. To develop these screening criteria, EPA compiled available Ambient Water Quality Criteria (AWQC) for both chronic and acute exposures of both freshwater and saltwater organisms. The Agency selected the lowest available AWQC for a given constituent and multiplied it by a factor of 100 to derive a liquid waste or leachate concentration that accounts for possible dilution that may occur if the waste is released to surface water.

- Water Resource Damage Screening Criteria. To derive these criteria, EPA assembled the following benchmarks for each constituent detected in the mineral processing waste samples: primary and secondary Maximum Contaminant Levels (MCLs) for drinking water; taste and odor thresholds; National Academy of Science (NAS) recommendations for livestock watering and irrigation; and the AWQC for fish ingestion. Whenever an MCL was available, EPA used that value multiplied by a factor of 10 to derive a liquid waste or leachate concentration that accounts for possible dilution that may occur if the waste is released to ground water. When an MCL was not available, EPA selected the next lowest value and multiplied that value by either a factor of 10 or a factor of 100 to derive a liquid waste or leachate concentration that accounts for possible dilution if the waste is released to ground water (factor of 10) or surface water (factor of 100).

EPA pooled all the available data for a given waste stream and compared measured constituent concentrations in solid and liquid samples to the relevant screening criteria. For this evaluation, the Agency considered only concentrations that were detected. Analyses for which a given constituent was not detected were not used to evaluate the hazard posed by the constituent. If a constituent concentration in any sample of a waste from any facility exceeded one of the screening criteria, regardless of the magnitude of the exceedance or the frequency of exceedances for the data as a whole, that constituent was considered a potential constituent of concern for the waste (for purposes of this conservative screening analysis).

The data used in the risk assessment include leachate concentrations from a number of leach tests, including the Extraction Procedure (EP), the Toxicity Characteristic Leaching Procedure (TCLP), and the Synthetic Precipitation Leaching Procedure (SPLP).[4] Because most of the available data are from EP leach tests, the Agency relied most heavily on these data in evaluating potential constituents of concern in leachate.[5] The Agency recognizes that the EP leachate test is a relatively conservative approach for estimating the concentrations of some metals in leachate generated from the mineral processing wastes as they are currently managed. To determine the extent to which EP leachate data differ from SPLP leachate data, the Agency evaluated the differences between SPLP and EP leachate concentrations for the special wastes. This evaluation demonstrated that although the two tests provide similar results for many constituents in most wastes, some constituents (e.g., iron, lead, zinc, aluminum, cadmium, copper, nickel) are commonly present in higher concentrations in EP leachate than in SPLP leachate. A smaller number of constituents (e.g., arsenic, vanadium, molybdenum, barium) are commonly found in higher concentrations in SPLP leachate than EP leachate. Given the conservative nature of this screen and the preponderance of EP leachate data, the Agency believes that it is appropriate to use EP leachate data in this evaluation of mineral processing wastes.

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[4] EPA Methods 1310, 1311, and 1312, respectively.

[5] The recently promulgated (March 29, 1990) Toxicity Characteristic (TC) will replace the EP Toxicity characteristic as of its effective date. Because, however, the wastes considered in this report are, for the most part, unlikely to contain the organic constituents that were added by the TC, and because the regulatory levels for metals employed in these two methods are identical, the Agency believes that any conclusions regarding the inherent toxicity of the wastes considered in this report are likely to remain valid once the TC becomes effective.

EPA acknowledges that this use of the EP leachate data differs from the approach used in the Agency's recent rulemakings on mineral processing wastes (reinterpreting the scope of the Mining Waste Exclusion), but believes that there are sound reasons for adopting this approach. In the rulemakings, EPA collected and used limited SPLP data in order to establish which wastes qualify as "low hazard" and are thus eligible for detailed study in this report (i.e., use of the SPLP data was a reasonable approach for selecting the wastes to be studied, because wastes that exhibit hazardous characteristics under the SPLP test are clearly not low hazard). For purposes of actually conducting a risk assessment, however, relying primarily on the EP leachate data is a reasonable, though more conservative (i.e., protective) approach.

Evaluation of Constituent Persistence and Mobility. Even though a constituent may exist in a waste in potentially harmful concentrations, the constituent may pose little or no risk if it rapidly degrades in the environment or if it is unable to migrate away from the waste management unit. Therefore, for each potential constituent of concern identified based on its concentration relative to screening criteria, EPA evaluated the extent to which the constituent can persist and migrate in the environment.

Because most of the constituents that are present in mineral processing wastes in elevated concentrations are metals that do not degrade in the environment, the evaluation of persistence was largely a moot exercise. However, for the organic constituents detected in elevated concentrations in a few of the wastes, EPA evaluated the constituents' persistence by considering their degradation rates in ground water, surface water, and air.

To evaluate constituent mobility, the Agency considered the tendency for each constituent to bind to soil when present in ground water and the potential for organic constituents to be released to the air by volatilization. For the analysis of ground-water mobility, EPA examined the sorption coefficient (K_d, a measure of the degree to which contaminants bind to soil) for each inorganic constituent and assumed that inorganic constituents with K_d values less than 20 ml/g are relatively mobile in ground water, while inorganics with K_d values greater than 20 ml/g are relatively immobile in ground water. This assumption is based on the results of previous modeling exercises that demonstrated that constituents with K_d's greater than 20 ml/g often migrate so slowly in ground water that they do not reach distances of interest within 200 years (i.e., their potential to endanger human health and damage water quality over typical modeling horizons is extremely limited).[6] For organics that were detected, EPA evaluated each constituent's Henry's Law constant, a parameter that indicates the degree to which a constituent is likely to be released to air by volatilization from aqueous solution.

Conclusions from Intrinsic Hazard Evaluation. Given the conservative (i.e., protective) nature of the screening criteria, waste constituents that are present in concentrations below the screening criteria are not likely to pose a risk to human health or the environment. On the other hand, exceedances of the screening criteria should not, in isolation, be interpreted as proof of hazard. Therefore, if a constituent in any sample of a waste exceeded a screening criterion, and if the constituent was considered persistent and mobile in the environment, EPA concluded that risk posed by the waste should be evaluated further. EPA then proceeded to the next step of the risk assessment to evaluate the potential for constituents of concern to be released into the environment and migrate to receptor locations, by considering the existing waste management practices and environmental settings of the facilities that generate the waste.

Evaluation of Release, Transport, and Exposure Potential

In this second step of the risk assessment, the Agency evaluated the potential for the waste to pose risks to human health and the environment based on its current management at the 91 mineral processing facilities. In particular, EPA assessed facility-specific information on a number of factors that relate to the potential for the waste to be released into ground water, surface water, and air, and subsequently transported to locations where humans or aquatic organisms could be exposed.

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[6] U.S. EPA. 1987. Onshore Oil and Gas Exploration, Development, and Production: Human Health and Environmental Risk Assessment (Technical Support Document). Office of Solid Waste, December.

The Agency assessed ground-water release, transport, and exposure potential by evaluating the waste leachability, management unit characteristics (e.g., presence of engineered controls), hydrogeological setting characteristics (e.g., net recharge, depth to aquifer, nature of subsurface material), and distance to potential exposure points. To assess surface water release, transport, and exposure potential, EPA considered the distance to the nearest downhill surface water, the likelihood of overland releases of waste from the unit in stormwater run-off, the likelihood that contaminated ground water could discharge to surface waters, the type and size of the nearby surface water, and the distance to potential exposure points. Similarly, air pathway release, transport, and exposure potential was assessed by evaluating the characteristics of the management unit related to the potential for wind erosion and suspension of dust from vehicular disturbances, meteorological conditions, and the proximity of the unit to potential exposure points. When possible, EPA used information developed from the damage case analyses to support the assessments of release, transport, and exposure potential for all three pathways. For the phosphoric acid and elemental phosphorus sectors, EPA also relied upon previous Agency analyses[7,8] of radiation risks to supplement the data collected specifically for the present assessment of risk. Based on the findings of this effort, EPA developed qualitative conclusions on the potential for the wastes to cause impacts by each of these release and exposure pathways.

The scope of this portion of the analysis was limited in several important ways. EPA evaluated only the baseline hazards of the wastes as they were generated and managed in 1988 at the 91 facilities of interest. Moreover, the Agency did not assess: (1) risks of off-site use or disposal of the few wastes that are ever managed off-site; (2) risks associated with potential future changes in waste management practices or population patterns; or (3) risks of alternative management practices. EPA is unable to extend its assessment of risk along any of these three dimensions because of insufficient data. However, EPA does evaluate the hazards of off-site use or disposal in the context of certain damage cases, as well as the hazards of alternative management practices in the waste-specific discussions of management alternatives and potential utilization.

Risk Modeling

EPA's risk assessment methodology has been designed to develop and present the key determinants of risk in a form that is objective and readily accessible to interested parties. Risk is a function of (1) the physical and chemical characteristics of a particular waste (particle size, constituent concentrations), (2) the manner in which the waste is managed, and (3) site-specific environmental conditions (e.g., net recharge) and proximity to potential receptors (e.g., surface water, drinking water wells, wetlands).

Only if the evaluation of these three factors in combination indicates that chemical/radiological contaminants could reach potential receptors in potentially harmful concentrations is there a need to quantify the magnitude of any such exposures and their associated risks. Risk modeling is a valuable analytical tool that the Agency has employed on an as-needed basis to resolve the issue of potential risk in cases where the result of evaluating the three factors is either ambiguous or indicates a potentially serious risk that requires more detailed study.

In addition, results obtained by assessing risk-related factors are compared with the findings of the damage case collection effort that is described below, as a final "reality check." The data that EPA has collected to conduct the risk assessment exercise is incomplete in some cases (waste constituent data) and of limited precision in others (e.g., aquifer characteristics). Consequently, review of damage case information provides a valuable means of filling information gaps and developing a more complete view of potential risk. At the same time, however, documented damages associated with management of a given waste do not necessarily prove that chronic human health or environmental risk is significant. In some instances, for example, damages may have occurred at sites that are no longer active (i.e., may have different environmental

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[7] U.S. EPA. 1989. Risk Assessments: Environmental Impact Statement for NESHAPS: Radionuclides, Volume 2 (Background Information Document). Office of Radiation Programs. September 1989.

[8] U.S. EPA. 1990. Idaho Radionuclide Study. Office of Research and Development. Las Vegas Facility. Las Vegas, NV. April 1990.

settings), or may reflect the effects of unusual circumstances (e.g., severe storms). Accordingly, EPA's evaluation of damage case information in the context of establishing the need for risk modeling accounts for whether the documented damages reflect actual site conditions and whether the types of observed impacts can be quantified by the risk model.

If, at the end of this multi-stage process, EPA finds no significant risk potential and no documented cases of environmental damage associated with a particular special waste, then the Agency believes that (1) the relevant RCRA §8002(p) study factors have been addressed adequately, and (2) further analysis in the form of risk modeling would not influence the results of the Agency's analysis or EPA's conclusions regarding the adequacy of current waste management controls.

Otherwise, EPA conducted further analysis of risk using more sophisticated quantitative methods. The Agency identified the wastes, facilities, and potential release/exposure pathways that appear to pose relatively high risks, then used a computer model to quantitatively estimate risks for those wastes, facilities, and pathways with the highest risk potential. EPA estimated risks on a facility-specific basis using the data and information sources outlined above.

EPA used the model "Multimedia Soils" (MMSOILS) to estimate the risks posed by mineral processing wastes. MMSOILS was originally developed for EPA's Office of Health and Environmental Assessment[9] to estimate the human exposure and health risk associated with contaminated soils at hazardous waste sites. The model has undergone extensive peer review by several offices of EPA and members of the academic community. For the purpose of this study, OSW revised MMSOILS to include algorithms for predicting contaminant releases from various waste management units, such as waste piles, landfills, and surface impoundments. Appendix C-2 of this report provides a more detailed summary of MMSOILS and how it was applied in this analysis.

The Agency used MMSOILS to estimate the following risk measures:

- Cancer and chronic non-cancer risks for maximally exposed individuals via the inhalation and water ingestion pathways, assuming an individual breathed contaminated air or ingested contaminated water over an entire lifetime (assumed to be 70 years). The cancer risk estimates represent the estimated incremental probability of occurrence of cancer in an exposed individual, over that individual's lifetime. The measure used for non-cancer risk was the ratio of the maximum estimated chemical dose to the dose of the chemical at which health effects begin to occur.
- Risks to aquatic organisms caused by chronic exposures to surface water contamination. The risk measure used for aquatic ecological risk was the ratio of the maximum estimated surface water concentration of a chemical to the chronic AWQC for that chemical.
- Potential contamination of air and water in excess of resource damage criteria. The measure developed for potential air quality degradation was the ratio of maximum estimated concentrations of airborne lead to the NAAQS for lead. The measures developed for potential water quality degradation were the ratios of contaminant concentrations at various downgradient/downstream distances to non-health related benchmarks.

To estimate each of these risk measures, EPA modeled the wastes using median constituent concentrations, including median concentrations in waste leachate as measured using the EP leach test. As discussed above, EPA believes that use of the EP leachate data is a reasonably conservative approach. The Agency believes it was appropriate to use median concentrations because the values used for all of the other model variables (including waste volume, management practice, and environmental setting parameters) were also typical or central values generally designed to yield "best estimates" of risk.

Finally, EPA considered only chronic, steady-state releases and a 200-year modeling period. Releases from units with liners or other engineered controls were assumed to begin several years after the units were first put into operation, and then to progressively increase in order to simulate gradual deterioration of the liners/controls after the units are closed. Otherwise, releases to the environment were assumed to occur at a constant rate because the readily available input data on environmental setting (e.g., annual precipitation, stream flow, annual average wind speed) are reported as steady-state parameters. The Agency considered a 200-year modeling period because previous EPA risk modeling studies have indicated that this length of time is adequate to determine whether model results will indicate potential risk, i.e., extending the modeling period is unlikely to influence the results of the risk modeling exercise.

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[9] ICF Technology, Inc. 1988. Methodology for Estimating Multimedia Exposures to Soil Contamination (Draft). Prepared for U.S. EPA Exposure Assessment Group, Office of Health and Environmental Assessment, Office of Research and Development, December 28.

Documented Cases of Danger to Human Health or the Environment

Section 8002(p)(4) of RCRA requires that EPA's study of mineral processing wastes examine "documented cases in which danger to human health or the environment has been proved." In order to address this requirement, EPA defined danger to human health and the environment in the following way. First, danger to human health includes both acute and chronic effects (e.g., exceedances of drinking water standards, directly observed health effects such as elevated blood lead levels or loss of life) associated with management of mineral processing wastes. Second, danger to the environment includes: (1) impairment of natural resources (e.g., contamination of any current or potential source of drinking water); (2) ecological effects resulting in impairment of the structure or function of natural ecosystems and habitats; and (3) effects on wildlife resulting in impairment to terrestrial or aquatic fauna (e.g., reduction in species' diversity or density, impairment of reproduction).

This section describes the approach the Agency used to address the §8002(p)(4) requirement, including the "test of proof" used and the methods used to identify potential cases, collect documentation, and verify the accuracy and completeness of the resulting case studies. In addition, this section provides a discussion of the limitations associated with interpretation of the results obtained. Throughout the discussion, cases where danger has been proved are often referred to as damage cases.

"Test of Proof"

The statutory requirement is that EPA examine proved cases of danger to human health or the environment. As a result, EPA developed a "test of proof" to be used for determining if documentation available on a case proves that danger/damage has occurred. This "test of proof" contains three separate tests; a case that satisfies one or more of these tests is considered "proved." The tests are as follows:

1. Scientific investigation: Damages are found to exist as part of the findings of a scientific study. Such studies include both extensive formal investigations supporting litigation or a State enforcement action and the results of technical tests (such as monitoring of wells). Scientific studies must demonstrate that damages are significant in terms of impacts on human health or the environment. For example, information on contamination of a drinking water aquifer must indicate that contamination levels exceed drinking water standards.
2. Administrative ruling: Damages are found to exist through a formal administrative ruling, such as the conclusions of a site report by a field inspector, or through existence of an enforcement action that cited specific health or environmental damages.
3. Court decision: Damages are found to exist through the ruling of a court or through an out-of-court settlement.

Identification of Potential Damage Cases

EPA identified potential damage case sites by compiling a list of: (1) currently operating mineral processing facilities based on industry and government sources (e.g., Bureau of Mines); (2) mineral processing facilities on the National Priorities List under CERCLA; (3) and facilities identified in public comments on the rulemakings that established the wastes to be studied in this report. Additional facilities were added to this list during the information collection process described below when state or federal contacts indicated that additional facilities should be considered.

Information Collection

EPA used direct telephone and written contacts with state and federal agencies and individuals, as well as follow-ups to such contacts, to collect information on damage cases. Contacts were made with agencies in all of the states with one or more of the facilities on the list of potential damage cases (developed as described above). Specific sources of information included:[10]

- Relevant state or local agencies, including state environmental regulatory agencies, mineral or mining regulatory agencies, state, regional, or local departments of health, and other agencies potentially knowledgeable about damages related to mineral processing operations;
- Professional or trade associations; and
- Public interest or citizen's groups.

The Agency then visited some of the states contacted to collect information about specific sites from state files. Selection of states to be visited was based on: (1) the type and complexity of site-specific information available in state files (based on the contacts with state personnel); (2) EPA's ability to obtain data of interest from state personnel without visiting the state; (3) the number and type of mineral processing facilities contained within the state; and (4) environmental factors unique to the state such as climate, geology, hydrology, and surface water features. Where feasible, information was collected by mail from state personnel.

During visits to state agencies, which were made during the period from November 1988 to February 1990, EPA reviewed documentation on sites on the list of potential damage cases, and collected documentation on those sites that appeared to meet one or more of the "tests of proof". Follow-up contacts were also made with agencies, groups, and individuals that the state files or personnel indicated might have additional relevant information. In addition, EPA also visited some of the mineral processing facilities in conjunction with visits to state agencies.

Damage Case Preparation and Review

Following completion of the data collection efforts, EPA prepared summaries of the information obtained for documented damage case sites. EPA then requested comments on the drafts of these summaries from the state and federal agency personnel who assisted in providing the information upon which the summaries were based. EPA specifically requested that the reviewers verify any interpretations of the available data and identify any available and relevant data that were not included. The comments that EPA received were used to prepare the final summaries,[11] which in turn provide the basis for the discussions of damage case findings that are included for each type of mineral processing waste covered by this report.

Limitations of the Damage Cases

The damage case findings that resulted from the process described above must be interpreted with care, for several reasons. First, mineral processing facilities are often co-located with mineral extraction and beneficiation (i.e., mining) operations; the mineral processing wastes covered by this report often are or have been co-managed with other wastes. As a result, it is sometimes difficult to determine if the documented damages were caused by stack emissions, direct discharges to surface water, etc., rather than mismanagement of mineral processing special wastes, or if waste management practices have been shown to have caused the observed damage, which type(s) of wastes (e.g., extraction or processing wastes) caused or contributed to the damage. The sites included in this report are those for which the available data indicate that the documented damages are attributable at least in part to mineral processing waste management.

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[10] Although many of the above sources were contacted in developing certain damage cases, the damage case gathering effort relied principally on information available through EPA regional offices and state and local regulatory agencies.

[11] Detailed information on the case study findings is provided in the public docket supporting this report.

Second, the extent to which the findings can be used to draw conclusions concerning the relative performance of waste management practices among states or across industry sectors is limited by variations in requirements and recordkeeping. Recordkeeping varies significantly among states. A few states have complete and up-to-date central enforcement or monitoring records on mineral processing waste management facilities within the state. Where states have such records, information on damages may be readily available. Thus, states that have environmental monitoring information on mineral processing facilities may appear to contain more sites where damages have resulted from management of special wastes from mineral processing.

More often, enforcement and monitoring records are incomplete and/or distributed throughout regional offices within the state. Additionally, because mineral processing special wastes are not regulated under Subtitle C of RCRA, many states do not specifically regulate solid waste management at mineral processing facilities. Indeed, some states have passed legislation specifically forbidding the responsible state regulatory agency to impose regulations on solid waste management at mineral processing facilities that are more stringent than the federal regulations. As a result, monitoring and, thus, detection of problems at mineral processing facilities has occurred on a very limited basis, if at all, in some states. Therefore, while damages similar to those identified in states where mineral processing special waste management activities are monitored may exist in states that do not have an environmental monitoring or regulatory program for mineral processing special wastes, these damages could not be identified for this report.

Third, data collection efforts generally were focused on the central office of the appropriate state agencies. In some instances, information may have been available at a state regional office that was not available in the central office. Furthermore, researchers' ability to collect data at each office sometimes was limited by the ability of each state to provide staff time to assist in the research.

Finally, because environmental contamination resulting from waste disposal practices often takes many years to become evident, documented examples of danger that have resulted from particular waste disposal practices may reflect conditions that no longer exist. Specifically, process feedstocks, processing operations, waste characteristics, and/or waste management practices may have changed. As a result, damage cases associated with a waste do not necessarily demonstrate that practices used to manage waste that is currently being generated or regulations are in need of change. On the other hand, failure of a site to exhibit documented damages at present does not necessarily suggest that waste management has not or will not cause damage. The Agency believes, however, that information on dangers posed by past waste management practices is useful in demonstrating the potential for environmental and human health impacts when hazardous constituents are released.

2.2.3 Existing Federal and State Waste Management Controls

Federal Controls

EPA's objective in this analysis was to identify and evaluate the existing regulatory controls over the management of special mineral processing wastes that have been promulgated by agencies of the federal government, focusing on programs and requirements established by EPA. This characterization is necessary for two reasons. First, some states do not have EPA-approved programs for regulating discharges of contaminants to surface waters (NPDES) or regulating the management of hazardous wastes under Subtitle C of RCRA, or approved RCRA Subtitle D state solid waste management plans under 40 CFR Part 256. In these cases, federal EPA regulations take precedence. Second, the federal government has not delegated authority to the states for implementing some environmental protection statutes and regulations; thus, the federal government is responsible for their implementation.

The initial phase of the analysis examined the relevant statutes and regulations pertaining to hazardous waste, solid waste, air quality, and water quality as they might apply to the management of the mineral processing special wastes. The purpose of this review was to provide broad background information on the regulatory authorities available to the federal government that could affect the management of wastes generated from the extraction, beneficiation, and processing of ores and minerals.

The second phase of this analysis was to identify and evaluate any specific regulations, such as NESHAPs, effluent limitations, emission standards, MCLs, etc., that have been promulgated under authority of any of the major federal environmental statutes that pertain to any of the 20 special mineral processing wastes.

The final phase of this analysis involved contacting Regional EPA staff in those states that do not have federally approved programs for implementation of the major environmental statutes (e.g., RCRA, CWA), as well as relevant staff within other federal agencies and departments (e.g., Bureau of Land Management, U.S. Forest Service), and performing a detailed regulatory analysis of the implementation of all existing federal statutes and regulations that pertain specifically to the management of the 20 special mineral processing wastes. Summaries of the results of this process have been incorporated into the commodity-specific chapters that follow. Detailed findings of EPA's analysis can be found in Appendix D-1 to this report.

Requirements in Selected States

EPA's goal in this analysis was to determine the current regulatory stance of states with regard to the mineral processing wastes generated by the 12 commodity sectors addressed in this report. The analysis serves more generally to help characterize current waste management and disposal practices taking place as a result of state regulation. This characterization is also, to a limited extent, used to establish a baseline for the analysis of costs and other impacts resulting from current and prospective regulatory requirements.

The first step in the analysis focused on reviewing material in a report on state-level regulation of mining and mineral processing wastes ("CDM report").[12] EPA examined the material in the CDM report that pertains to all 29 states containing one or more facilities considered in this report, and summarized portions of the hazardous waste, solid waste, air quality, and water quality statutes and regulations that are relevant to the current disposition of the special study wastes. Although the CDM report provides a general overview of state statutory and regulatory requirements addressing wastes from the extraction, beneficiation, and processing of ores and minerals in all 50 states, it was not designed to provide the detailed analysis of the scope, and in particular, the implementation of regulations that address mineral processing wastes, that EPA believes is necessary for this Report to Congress.

The second step of EPA's analysis, therefore, was to perform more detailed review of individual state statutes and regulations. Time and resource constraints made it impossible to perform a detailed regulatory analysis on all of the states that contain facilities that generate special mineral processing wastes. Consequently, this step in the analysis involved selecting a representative sample of the 29 states for further analysis. The goal of this selection process was to balance the need for comprehensive coverage of the mineral commodity sectors under study in this report with the need to work with a manageable number of states.

To ensure that the selected states provided comprehensive coverage of the sources of the mineral processing wastes in question, EPA employed the following criteria: (1) the percentage of facilities in each state and in each sector covered by the regulatory analysis; and (2) the percentage of total waste volume in each waste stream and sector covered by the regulatory analysis. Exhibit 2-4 displays the results of the evaluation of these criteria, which led to the selection of 18 of the 29 states for more detailed regulatory analysis. In selecting the 18 states, EPA was able to cover at least two-thirds of the facilities in all but one of the sectors (titanium tetrachloride) and at least 80 percent of the waste volume generated in each sector. Because a number of firms designated information as business confidential, EPA cannot publish all of the waste volume percentages; the Agency did, however, examine all of the waste volume data, including data from facilities that designated their waste generation rates as confidential, to ensure that the 18 studied states adequately represent the entire population of concern. The geographic distribution of the 18 selected states is displayed in Exhibit 2-5. The result of this step in the analysis was a summary, organized in a sector-by-sector format, that contains detailed information on the relevant statutes and regulations from the 18 selected states, along with shorter summaries addressing the eleven remaining states.

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[12] Camp, Dresser, and McKee Federal Programs Corporation (CDM). 1989. State Regulation of Solid Wastes from the Extraction, Beneficiation, and Processing of Non-Fuel Ores and Minerals, June 2, 1989. Prepared for U.S. Environmental Protection Agency, Office of Solid Waste; Document Control Number: T1142-R00-DR-DELC-1.

Exhibit 2-4
Summary of Results of Selection Criteria Evaluation

Sector	Total Number of Facilities	Number of Facilities in Study States	Percent of Facilities in Study States	Percent Waste Volume Generated in Study States	Notes on Volume Data[a]
Alumina	5	4	80	93	
Chromate	2	2	100	NA[b]	2 of 2 facilities CBI
Coal Gasification	1	1	100	100	
Copper	10	9	90	90	3 of 10 facilities CBI
Elemental Phosphorus	5	5	100	NA[b]	3 of 5 facilities CBI
Ferrous Metals	28	19	68	80	2 of 28 facilities CBI
Hydrofluoric Acid	3	3	100	100	1 facility NR[c]
Lead	5	4	80	NA[b]	3 of 5 facilities CBI
Magnesium	1	1	100	100	
Phosphoric Acid	21	20	95	100	2 of 21 facilities CBI
Titanium	9	5	56	NA[b]	8 of 9 facilities CBI
Zinc	1	1	100	100	

(a) CBI = Confidential Business Information
(b) NA = Insufficient data to calculate accurately due to Confidential Business Information (CBI) status
(c) A single hydrofluoric acid facility owned by Dupont did not submit a survey response

While this more detailed study partially resolved the regulatory status of special mineral processing wastes, EPA found that the scope of state programs was not always clear from the state statutory and regulatory language that was reviewed. The final step of EPA's analysis, therefore, consisted of contacting state officials involved with the implementation of legal requirements in order to learn how those statutes and regulations are interpreted in practice, and to obtain facility-specific implementation information. The information compiled from these contacts was combined with the existing information on statutory and regulatory requirements to produce a final implementation analysis, which gives the clearest representation of the existing regulatory structure applicable to the 20 mineral processing wastes generated by the twelve commodity sectors considered in this Report to Congress.

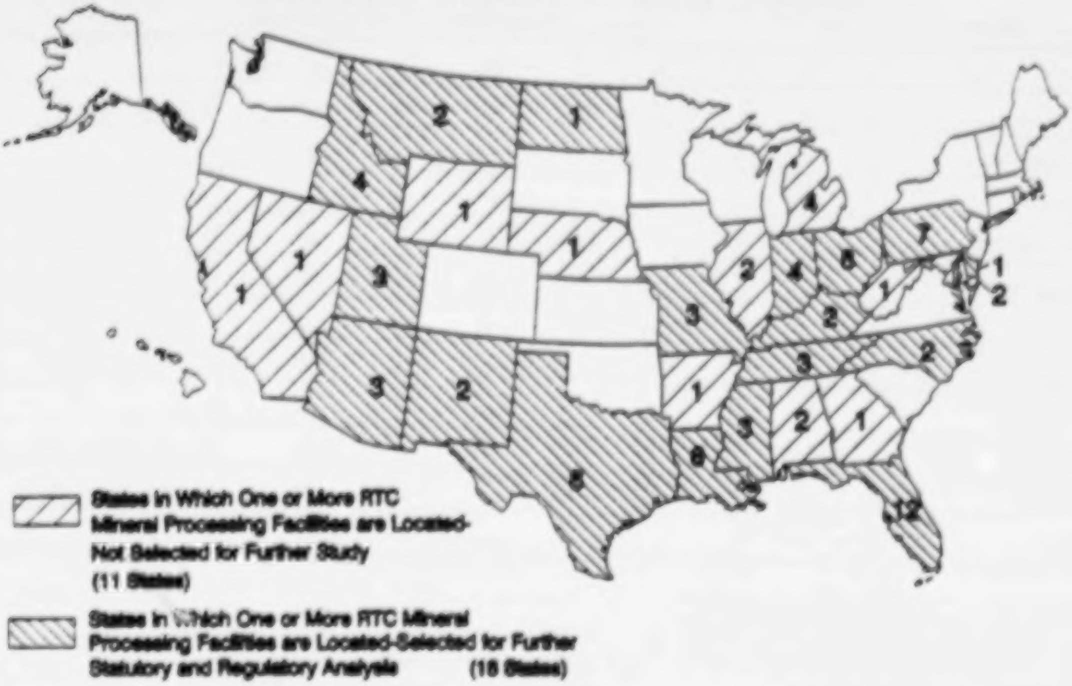
The findings of this analysis have been included in the sector-specific chapters that follow. For each of the 18 states containing a facility within a given sector, EPA has provided a description of the regulatory controls that apply to the management of special mineral processing wastes. A copy of the complete analysis can be found in Appendix D-2 to this report.

2.2.4 Waste Management Alternatives and Potential Utilization

Section 8002(p) of the RCRA statute requires that EPA consider alternatives to current disposal methods, as well as the current and potential utilization of the wastes addressed by the Report to Congress. In order to accomplish this, this report identifies demonstrated alternatives for waste management and utilization. The costs, current use, potential use, and environmental impact of each alternative are evaluated to the extent permitted by the information available.

Because the primary purpose of this report is to support a decision as to whether the mineral processing special wastes are to be regulated as hazardous wastes, EPA has focused its efforts and the discussion of waste management alternatives presented herein on those wastes that the Agency considers to

Exhibit 2-5
Distribution of States Selected For Further Statutory and Regulatory Analysis for the Mineral Processing Wastes Report to Congress


3
2
1
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7
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4
5
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1
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3
2
3
3
2
3
2
1
1
6
3
2
1
5
12
States In Which One or More RTC Mineral Processing Facilities are Located-Not Selected for Further Study (11 States)
States In Which One or More RTC Mineral Processing Facilities are Located-Selected for Further Statutory and Regulatory Analysis (18 States)

* The number in each state indicates the number of RTC mineral processing facilities located in the state.

be candidates for Subtitle C regulation. Wastes that exhibit no intrinsic hazard and pose no significant threat to human health or the environment under any realistic management scenario are not candidates for Subtitle C regulation. Therefore, extensive analysis and discussion of the ways in which facilities that generate such wastes might react to hazardous waste regulation is, in the Agency's view, unnecessary, because the question is moot. EPA has, nonetheless, provided (at a minimum) short discussions for each of the 20 special wastes considered in this report addressing potential waste management/utilization alternatives.

Methods

The first step in evaluating the alternatives for managing and utilizing the special mineral processing waste streams was to identify and obtain (through the National Technical Information Service and inter-library loans) any documents containing information on current or alternative waste management practices. Once documents from various sources were received, they were reviewed, and potentially useful information was extracted and organized according to the waste management or utilization option(s) to which it pertained. Alternatives for which there was insufficient information with which to evaluate the alternative are not discussed in this report, nor does the report consider alternatives that are experimental or unproven (i.e., have not seen full-scale application).

Information Collection

Computer-assisted literature searches were the primary means of identifying documents with information on the management and utilization of the special waste streams, though useful bibliographies were also obtained from government agencies, trade associations, and research institutions. Information contained within the documents was supplemented by reviewing the 1989 National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF Survey), and through direct contacts with private industry, trade associations, government agencies, contractors, and researchers.

More than 3,000 documents were identified as being potentially useful, primarily as a result of key word searches. A number of criteria were used to critically evaluate the 3,000 references and reduce the number of documents actually obtained and reviewed. Documents having titles with no clear relationship to any of the RTC study factors were eliminated from the Agency's preliminary list of potential information sources. EPA set priorities for procurement of the remaining documents after reviewing their abstracts (or key word descriptors if an abstract was not available), the time for delivery, and cost. Out of the possible 3,000 documents, over 300 were received and reviewed.

Additional information has been obtained through direct contact with Commodity Specialists and researchers at the U. S. Bureau of Mines, trade associations (e.g., the Florida Institute of Phosphate Research, The Fertilizer Institute), university researchers, and companies with some involvement in the management or utilization of one or more of the special study wastes. A comprehensive list of references that were collected and used by EPA in preparing this report may be found in Appendix B-5.

Evaluation of Alternatives

At a minimum, EPA's evaluation of each option includes a brief description of what the option involves (e.g., processing steps, equipment, and transportation); what is known about the current and potential use of the alternative; a discussion of the factors relevant to its regulatory status; and a discussion of the alternative's feasibility with respect to its cost and/or social acceptability. (The term "social acceptability" refers to whether an alternative is perceived to pose a potential threat to human health or the environment. Even in the absence of supporting data, perceived threats can influence the decisions of regulators, waste generators, and parties that might utilize a waste material.)[13] Where the information available allows, the discussion has been expanded to include data on costs, waste generation rates, and the chemical and physical characteristics of any waste management/ utilization residues. In many instances, the available data were not sufficient to allow EPA to evaluate the human health and environmental protection provided by the waste utilization and management alternatives identified. As a result, discussion of these options does not imply that EPA endorses their use.

2.2.5 Cost and Economic Impacts

Section 8002(p) of RCRA requires EPA to analyze "alternatives to current disposal methods" for solid wastes generated from the extraction, beneficiation, and processing of ores and minerals. EPA is also required to analyze "the costs of such alternatives." This section discusses methods for evaluating the costs and associated economic impacts of alternative waste management practices for the twelve mineral processing industry sectors and 20 special mineral processing wastes covered in this report. The analysis of costs and impacts is limited in scope to those waste streams that are candidates for regulation under Subtitle C of RCRA, i.e., those that exhibit one or more characteristics of hazardous waste and/or that have been associated with documented cases of danger to human health or the environment.

Costs may be imposed upon facility operators if changes in the regulatory requirements that apply to special mineral processing wastes management occur. The scope of this analysis is limited to the cost and economic impacts that would be associated with placing the wastes into three potential regulatory scenarios, focusing on the consequences of regulating these materials as hazardous wastes under Subtitle C of RCRA. EPA has attempted to predict how facility operators would react to having their wastes brought under the purview of different solid/hazardous waste management regulatory regimes, and has estimated the costs and impacts of the available waste management options under each regulatory scenario. EPA's approach in performing this analysis was to delineate all of the applicable requirements comprising each regulatory scenario, then develop plausible waste management sequences, or "trains", for each of the potentially affected special mineral processing wastes. Plausible management practices or trains are affected by the physical and chemical characteristics of the wastes in question, and by waste generation rates (all of which are, by definition, large), as well as by specific federal statutory and regulatory solid and hazardous waste management requirements. The ways in which prospective regulatory requirements translate into the "on the ground" waste management strategies that would be employed by affected facility operators are described in Appendix E-3 to this document.

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[13] Collins, R.J. and R.H. Miller. 1976. Availability of Mining Wastes and Their Potential for Use as Highway Material - Vol. I, Classification and Technical Environmental Analysis. FHWA-RD-76-106, prepared for the Federal Highway Administration, May. p. 167

In conducting its analysis of economic impact, EPA has utilized data on the recent performance of the individual industry sectors and the publicly-held corporations within them to characterize the financial condition of each potentially affected commodity sector. The incremental costs associated with alternative regulatory options are compared to several financial indicators in order to determine the relative magnitude of potential impacts. In addition, the Agency has conducted a qualitative analysis of market conditions facing each affected facility and sector, and has predicted the extent to which facilities potentially experiencing compliance costs would be able to pass through these costs to various input and product markets.

This section is organized into three major sub-sections in addition to this introduction. The first describes the four regulatory scenarios that have been developed for use in the cost analysis; the Agency believes that these scenarios span the range of the possible regulatory regimes that may be faced by mineral processors. The second sub-section provides a brief discussion of the costing assumptions and cost equations that have been used to conduct the analysis, and the third and final sub-section describes EPA's methodology for evaluating the economic impacts associated with changes in waste management costs.

Development and Application of Regulatory Scenarios

The waste management practices discussed in this report reflect the range of practices that are currently employed to manage special mineral processing wastes, as well as alternative management techniques that the Agency believes would be employed by facility operators in response to new regulatory requirements. They do not represent the only possible practices available, nor do they necessarily include the practices that would be explicitly required in the event of a change in regulatory status. Costs are estimated for four regulatory scenarios: (1) current management practices with no additional action required ("baseline"); (2) management practices required under full Subtitle C regulation ("Subtitle C"); (3) a less stringent set of management practices that could be implemented under Subtitle C regulation, allowing for the regulatory flexibility provided by RCRA §3004(x) ("Subtitle C-minus"); and (4) a scenario developed by EPA for this report that would address mineral production wastes under the auspices of RCRA Subtitle D ("Subtitle D-Plus").

Two of the alternatives to the baseline are based on Subtitle C of RCRA, and are immediately germane to the key regulatory decisions that EPA will make based upon this document and additional public comment (i.e., whether Subtitle C regulation of the 20 special wastes is or is not appropriate). Cost impacts of full Subtitle C regulation can be calculated with a relatively high degree of confidence because the waste management alternatives available under Subtitle C are well defined and have been extensively studied, at least for some industries. EPA has analyzed the Subtitle C-minus scenario because provisions of Section 3004(x) of RCRA, as added in the 1984 HSWA amendments to the Act, allow flexible Subtitle C regulation for hazardous wastes generated by the mining and mineral processing industries, as well as certain other special waste categories.[14] Under this provision, many significant RCRA requirements[15] for wastes may be modified

> "...to take into account the special characteristics of such wastes, the practical difficulties associated with implementation of such requirements, and site-specific characteristics, including but not limited to the climate, geology, hydrology and soil chemistry at the site, so long as such modified requirements assure protection of human health and the environment."

Costs associated with the remaining regulatory alternative, the "Subtitle D-Plus" management program, on the other hand, are intended to be illustrative only. Although EPA is in the process of developing a Subtitle D program for mineral extraction and beneficiation wastes, the specific elements of this program remain to be determined. Whether and to what extent the ultimate mining wastes regulatory program resembles the Subtitle D-Plus regulatory scenario described here cannot be known at this juncture. EPA has, nonetheless, estimated the costs and impacts of Subtitle D regulation of special mineral processing wastes in this report, in the expectation that some of these studied wastes may ultimately be regulated under the Subtitle D mining wastes program, in whatever form it is finally promulgated.

Management costs associated with each pertinent regulatory scenario are estimated for each facility being analyzed by identifying the specific items (and their costs) that are currently employed (in the baseline case) and that would be required under the regulatory alternatives. EPA utilized data contained in facility responses to the 1989 SWMPF survey to characterize current practices. The Agency then calculated the costs associated with each practice employed (e.g., design, construction, and operation of an unlined surface impoundment, waste stabilization, installation and operation of ground water, surface water, and/or air monitoring equipment); the sum of these costs is the total management cost at a given facility.

This technology- and facility-specific approach has resulted in management cost estimates that vary widely among facilities, even among those in the same commodity sector. For example, EPA's cost estimates for baseline practices account for the presence of waste management controls such as run-on and run-off control systems and ground water monitoring. Facilities that currently employ these controls have higher current (baseline) waste management costs (all else being equal) than facilities that do not. Consequently, prospective Subtitle C regulation, and its attendant technical requirements (e.g., run-on and run-off controls, ground water monitoring) have reduced compliance cost implications at such facilities. Because EPA's cost analysis relies upon individual cost elements rather than unified cost functions, this variability in current waste management cost and, therefore, the incremental waste management cost associated with regulatory alternatives, can be accounted for in full.

Baseline Scenario

The baseline regulatory scenario assumes that existing waste management practices will remain unchanged. The waste management practices discussed in the sector-specific chapters that follow comprise the waste management technologies employed under this scenario. In virtually all cases, assumed current waste management practices are based upon information submitted to EPA in the form of responses to the 1989 National Survey of Solid Wastes from Mineral Processing Facilities, supplemented by information obtained during visits to some facilities. In the few instances in which management practice information was missing or incomplete, the Agency assigned one or more management technologies based upon knowledge of the common practices used by other similar (e.g., same commodity sector and size of operation) facilities.

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[14] Specifically, cement kiln dust waste and fly ash, bottom ash, slag, and flue gas emission control wastes generated primarily from combustion of fossil fuels (principally coal).

[15] Specifically, RCRA sections 3004(c) through (g) (land disposal restrictions), (o) (minimum technology standards), (u) corrective action for continuing releases), and 3005(j) (permitting of interim status treatment, storage, and disposal surface impoundments).

The most common current waste management technologies for solid and some sludge materials include on-site, unlined landfills; waste piles without a cover or a base; gypsum stacks; and recycling. Wastewaters tend to be managed in on-site, unlined surface impoundments (some in combination with a gypsum stack), and in a few cases, synthetic- or clay-lined surface impoundments. Some portion of these wastewater streams is recycled at nearly all facilities.

Several of the facilities examined here, particularly in the ferrous metals commodity sector, already are interim status or permitted Subtitle C Treatment, Storage, and Disposal Facilities (TSDFs). Such facilities are already subject to many of the requirements that are evaluated in this report (e.g., Subtitle C permitting, financial assurance, corrective action for continuing releases requirements), and hence, would not experience incremental compliance costs associated with these specific regulatory requirements if the special waste(s) that they generate were to be removed from the Mining Waste exclusion. EPA has, accordingly, reflected this fact in conducting its cost and economic impact analysis.

The "Baseline" scenario for the industry sectors covered by this report would occur under a regulatory determination by EPA that the special mineral processing wastes that are currently excluded from regulation under Subtitle C of RCRA do not require regulation as hazardous wastes. Even with such a regulatory determination, however, some changes in waste management practices may be required. The mineral processing industry, which has historically been exempt from the federal hazardous waste management regulations under RCRA, has recently had this protection removed by a series of EPA rulemakings that were concluded on January 23, 1990 (55 FR 2322). As of the effective date of this latest rulemaking, all mineral processing wastes except the 20 specific wastes considered in this report are subject to regulation as hazardous wastes (i.e., under RCRA Subtitle C) if they exhibit one or more characteristics of hazardous waste. In addition, six mineral processing wastes have been listed as hazardous wastes (see 53 FR 35412, September 13, 1988). EPA believes that many of the facilities considered in this report generate wastes that are newly subject to these requirements. Consequently, existing "baseline" management practices that are currently applied to special wastes at some of these facilities may change even if these materials are not removed from the Mining Waste Exclusion.

In addition, several states have imposed or are in the process of imposing new regulatory requirements on the operators of mineral processing facilities. For example, the State of Florida has issued a policy directive requiring that all new phosphogypsum stacks or lateral expansions of existing stacks have a clay liner; the State Department of Environmental Regulation has also indicated that it plans to initiate a formal rulemaking process for the development of phosphogypsum management regulations.

In general, however, the scope of EPA's analysis is limited to an examination of special mineral processing waste management as it is currently conducted, that is, as reported by facility operators in the 1989 SWMPF Survey. Nonetheless, where appropriate, the Agency has indicated when and in what manner existing management practices are expected to change because of non-RCRA federal or state-level regulatory activity.

Full Subtitle C Scenario

The full Subtitle C ("Subtitle C") scenario examined here for the special wastes is based on the premise that any of the 20 wastes for which (1) existing practices have been shown to have caused environmental damages, or (2) have exhibited risk in the risk assessment process described above, including any that exhibit one or more RCRA hazardous characteristics (EP-toxicity, corrosivity, ignitability, or reactivity) may be regulated under Subtitle C and, thus, subject to the technical requirements of 40 CFR Part 264. The remaining wastes, which have not shown significant potential risk or documented damages and do not exhibit a hazardous characteristic, are assumed to not be candidates for Subtitle C (or Subtitle C-minus) regulation, and hence, have not been analyzed under these scenarios.

EPA has examined the full array of Subtitle C regulatory requirements, and has identified those that would be relevant from the standpoint of managing mineral processing wastes (some Subtitle C requirements, such as those addressing the management of used oil, solvents and dioxins, etc. are clearly not germane to the present study). Relevant regulatory provisions are summarized in Appendix E-1 to this document. The Agency then identified and categorized all of these requirements that might have cost implications. In other words, the focus of EPA's compliance cost analysis is on the specific regulatory requirements that would impose new costs on the operators of the mineral processing facilities considered in this study. These groups of cost-related requirements are listed in Exhibit 2-6 and serve as the starting point for EPA's compliance cost analysis. Additional detail regarding the manner in which EPA has computed the costs of these individual provisions is provided in Appendix E-3.

Subtitle C-Minus Scenario

To assess the potential costs and impacts of less stringent regulation, EPA has evaluated an intermediate Subtitle C scenario ("Subtitle C-Minus") that assumes that EPA exercises all of the regulatory flexibility provided by Section 3004(x) of RCRA. Section 3004(x) does not give EPA authority to waive Subtitle C requirements based on cost alone. Rather, this provision allows EPA to provide some regulatory flexibility to mitigate the economic impacts of Subtitle C regulation on the industries generating certain special wastes, provided that adequate protection of human health and the environment is ensured. This flexibility allows EPA to modify the relevant provisions to take into account the special characteristics of (in the current context) mineral processing wastes, practical difficulties in implementing the specific RCRA Subtitle C requirements, and site-specific characteristics.

For purposes of estimating the costs of this regulatory alternative in this Report to Congress, EPA has identified and evaluated what it believes would be the minimum allowable extent of regulation under Subtitle C (i.e., the maximum allowable application of regulatory flexibility) that comports with the statutory requirement of ensuring adequate human health and environmental protection. EPA stresses, however, that the hypothetical Subtitle C-Minus scenario analyzed here does not reflect the Agency's actual determination as to which Subtitle C requirements might be altered and to what extent through the 3004(x) mechanism for any of the wastes or industries studied in this report, though it does reflect an attempt to craft tailored Subtitle C requirements that are operationally and economically feasible at the facility level. Moreover, EPA believes that the scenario provides a meaningful "lower bound" for estimating the potential compliance costs that would be imposed under Subtitle C. In other words, estimated Subtitle C-Minus compliance costs and associated impacts are likely to understate the actual impacts that would be imposed if the special mineral processing wastes are withdrawn from the Mining Waste Exclusion, at least for some commodity sectors and facilities.

This scenario uses many of the same assumptions as the full Subtitle C regulatory scenario, with three notable exceptions:[16]

- The prohibition on placing liquids in Subtitle C landfills does not apply;
- Land Disposal Restrictions do not apply; and
- On-site waste management practices, for special mineral processing wastes meet only pre-HSWA Subtitle C technological requirements, rather than the minimum technology required under 3004(o) and 3005(j) of the amended RCRA statute.

Potentially hazardous wastes managed on-site are awarded this regulatory flexibility. Candidate Subtitle C wastes managed off-site, however, are assumed to be sent to facilities that comply with all provisions of Subtitle C. Most other assumptions made for the full Subtitle C regulatory scenario with respect to the choice of waste management technologies apply to the Subtitle C-minus regulatory scenario as well.

Nonetheless, one important aspect of the way in which EPA has evaluated the implications of RCRA §3004(x) is that site-specific variability in risk potential and waste-specific variability in existing management practices has been explicitly factored into the analysis. Subtitle C-Minus waste management requirements are less stringent at facilities at which the potential for contaminant release and transport are low than at facilities at which such potential is high. For example, all else being equal, requirements at a facility overlying shallow ground water with high local net recharge and porous soils are more stringent than at an otherwise similar facility located in an arid region with deep ground water and relatively impermeable soils. Additional detail

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[16] As explained further below, EPA has not estimated corrective action costs in preparing this report, though relaxation of corrective action requirements is a potentially significant aspect of RCRA §3004(x).

Exhibit 2-6

Regulatory Requirements: Subtitle C Scenario

Category	Requirement
RCRA §3010 Notification	• Notification
Permit Requirements	• Exposure Potential Information • Chemical and Physical Analysis of Waste(s) • Waste Analysis Plan • Site Security • Inspections • Location Standard Studies • Topographical Map • Ground-Water Protection Study
Preparedness and Prevention	• Internal Communication/Alarm System • Water Sprinkler System
Design and Operating Criteria	• Land Disposal Restrictions • Tank Requirements: - Secondary Containment - Construction Requirements • Surface Impoundment Requirements: - Existing – Liner or No Migration Demonstration - New – Double Liner, Leachate Collection System • Waste Pile Requirements: - Liner - Leachate Collection and Removal System - Run-on/Run-off Controls - Wind Dispersal Control • Landfill Requirements: - Existing – Liner and Leachate Collection System - New – Double Liner, Dual Leachate Collection System - Run-on/Run-off Controls - Wind Dispersal Control • Land Treatment Requirements: - Proof of Contaminant Degradation, Transformation, or Immobilization - Run-on/Run-off Controls - Wind Dispersal Control - Permit for Field and Greenhouse Testing - Soil/Liquid Monitoring - Crop Distribution Plan
Monitoring	• Ground-Water Monitoring
Corrective Action	• Corrective Action Plan • Corrective Action Activities - Source Control - Remediation
Closure	• Remove/Decontaminate Residues • Stabilize, Cover Waste(s)
Post-Closure Care	• Monitoring • Maintenance • Leachate Collection • Run-on/Run-off Control
Financial Responsibility	• Environment Impairment Liability • Sudden Release of Contaminants • Non-Sudden Release of Contaminants

regarding the development and application of the Subtitle C-Minus scenario to individual waste streams and facilities is provided in Appendix E-3 to this report.

Subtitle D-Plus Scenario

The third and final regulatory alternative considered by the Agency for this analysis of regulatory costs and impacts is regulation under one possible approach to a RCRA Subtitle D (solid, non-hazardous waste) program. The approach described here has been developed solely for analytical purposes by EPA staff, and is tailored to address some of the special characteristics of mineral processing wastes. The reason for inclusion of a Subtitle D scenario in this report is that the Agency is presently developing a tailored program to address mineral extraction and beneficiation wastes under Subtitle D, and could consider applying this program to any of the 20 mineral processing wastes that remain excluded from regulation under RCRA Subtitle C after the regulatory determination that will follow, and be based upon, this report and on changes made due to comments received from the public and inter-agency discussions.

Substantively, the Subtitle D-Plus program would be a state-implemented program based on a minimum set of federal technical criteria and provisions for state program primacy. The technical criteria contained within the program would consist essentially of provisions for the state establishment of media-specific performance standards for ground water, surface water, air, and soils/surficial materials. The Subtitle D-Plus scenario also contains technical criteria for a variety of required owner/operator activities, including design and operating criteria, monitoring criteria, corrective action requirements, closure and post-closure care criteria, and financial responsibility requirements. These prospective regulatory provisions are summarized in Appendix E-2 to this document. The Agency has also identified and categorized all provisions of the Subtitle D-Plus scenario having potential cost implications. These groups of requirements are listed in Exhibit 2-7 and serve as the starting point for EPA's compliance cost analysis. Additional detail regarding the manner in which these requirements have been applied to individual facilities is provided in Appendix E-3 to this document.

Costing Assumptions and Methods

This section provides a brief overview of the methodology and assumptions that EPA has used to estimate compliance costs for regulation of special mineral processing wastes under the four regulatory scenarios described above.

Costs of regulations can be viewed in two contexts, economic and financial. The two contexts consider regulatory costs in two very different ways for different purposes. The economic context considers impacts on society at large, while the financial context evaluates effects on firms, facilities, and other discrete entities. For this report, EPA has considered only the financial context, that is, impacts on firms and facilities. Thus, in keeping with the statutory directives articulated at RCRA §8002(p), EPA's analysis employs a financial perspective which attempts to evaluate the actual costs that would be incurred by those firms subject to regulation. The willingness and ability of firms to comply with the regulations (instead of discontinuing the regulated activity) are influenced by the magnitude and timing of compliance costs, market and competitive factors, and firm-specific financial considerations, such as the costs incurred by the firms to obtain capital.

Consequently, in conducting this analysis, EPA has employed data and assumptions that reflect the focus on the individual facility/firm. For example, the Agency has employed a discount rate that approximates the likely true cost of obtaining financing for regulatory compliance-related expenditures, rather than a "social" discount rate, or cost to society, and has computed costs on an after-tax basis, to better reflect the financial impacts that might be imposed by new regulatory requirements.

Exhibit 2-7
Regulatory Requirements: Subtitle D-Plus Program Scenario

Category	Requirement
Regulated Materials Characterization	Regulated Materials Characterization
Design and Operating Criteria	• Structural Stability • Run-on/Run-off Controls • Land Application Requirements • Biological Resources Protection • Site Access Control • Inspections • Location Standards · Floodplains · Seismic Zones, Unstable/Fault Areas · Karst Terrane · Wellhead Protection Areas • Unit-Specific Requirements: · Waste Piles · Landfills · Surface Impoundments · Gypsum Stacks · Tank Treatment Systems
Monitoring	• Ground-Water Monitoring • Surface Water Monitoring • Air Monitoring
Corrective Action	• Corrective Action Plan • Corrective Action Activities: · Source Control · Remediation
Closure	• Final Regulated Materials Characterization • Continued Compliance with Design and Operating Criteria • Closure Plan • Closure Activities · Run-on/Run-off Controls · Stabilization/Neutralization · Wind Dispersal Control · Removal of Materials, Decontamination (Tanks)
Post-Closure Care	• Continued Compliance with Design and Operating Criteria • Post-Closure Care Plan • Post-Closure Care Activities · Maintenance of Closure Activities
Financial Responsibility	• Environmental Impact Liability • Corrective Action • Closure/Post-Closure Care

Cost Estimating Methods

In EPA's cost estimating analysis, the first step was to estimate the costs of waste management activities and the distribution of these costs over time. The second step was to discount all future costs to the present and then calculate the equivalent annualized compliance cost (ACC), incorporating the specific requirements of the context being examined. The annualized compliance cost is the average annual cost (annuity) over the life of the facility that has the same total present value as the actual expenses incurred at the actual times. This method offers the distinct advantage of allowing comparisons between scenarios and among industrial sectors that may incur compliance costs of different types and/or at different times.

EPA has estimated the costs of waste management for each individual facility that may be affected by new regulatory requirements for up to four waste management scenarios. Cost equations developed from an engineering analysis of each technology are used to estimate the costs for each individual management practice used. The sum of the costs equals the total facility cost. Under three alternative regulatory scenarios examined here, four types of costs can be incurred:

- Capital investment costs, both direct and indirect, incurred initially and in each year that the technology is operated (e.g., construction of new disposal units). Capital costs incurred annually are treated as operating costs;
- Annual operating and maintenance (O&M) costs, both direct and indirect (e.g., materials, labor, utilities);
- Capital costs (direct and indirect) for facility closure; and
- Annual costs of post-closure care and maintenance.

Most of the facilities of interest are not currently required to perform formal closure and post-closure care activities. Accordingly, in EPA's analysis, most facilities are assumed to experience only capital and O & M costs under the baseline scenario.

Costing Equations

EPA has developed cost estimating equations that reflect the current waste management practices employed by the facilities of interest, as well as the practices that would be required under alternative regulatory scenarios. In analyzing each facility, total management costs are built up by determining which specific requirements apply (e.g., obtaining permits, installing run-on/run-off controls, constructing a tank treatment system), estimating the cost of each requirement for a given waste stream at the facility, and adding the costs of each requirement. EPA used these technology-specific costs to calculate the total annual compliance costs (ACCs) for utilizing a given management requirement. The ACC for a waste management practice is the sum of the ACCs for the treatment, storage, and disposal steps in that waste management practice. In this way, all costs of currently used management techniques are accounted for, and only the items that would actually apply at a particular facility are used in calculating incremental waste management costs.

Analytical Assumptions

In general, most of the waste streams considered in this report do not exhibit characteristics of hazardous waste. In conducting this cost analysis, EPA has assumed that waste streams are potentially hazardous at individual plants only if data submitted by industry or EPA sampling indicate failure of hazardous waste characteristic tests, for most waste streams.[17] In these cases, the waste(s) are assumed to be candidates for Subtitle C and Subtitle C-minus regulation, and are examined in the cost analysis on that basis. Otherwise, wastes are assumed to be non-hazardous, except for waste streams which may pose risks that are not addressed by current Subtitle C hazardous waste characteristics tests (e.g., radioactivity), or for which special circumstances justify a modified cost analysis approach.

For those wastes assumed to be candidates for regulation under one or more alternative scenarios, it is often the case that more than one management train would be available. In these instances, and in keeping with the profit-maximizing behavior expected of facility operators, the Agency selected the least-cost alternative for managing each waste under each regulatory scenario. The costs of each scenario/least-cost management practice combination were then compared to the estimated cost of current management practices, in order to develop incremental regulatory compliance costs.

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[17] The preponderance of evidence indicates that a small number of wastes are likely to exhibit hazardous characteristics at most (including unsampled) facilities; in its costing analysis, EPA has assumed that these wastes would exhibit characteristics of hazardous waste at all facilities unless actual sampling data indicated a contrary result.

In estimating costs for specific waste management technologies, the Agency made a number of costing assumptions, which are described in Appendix E-3 to this report. Detailed results of EPA's compliance cost analysis are presented in a technical background document that may be found in the supporting docket for this report.

Evaluation of Economic Impact

Section 8002(p) requires that EPA examine, in addition to incremental costs, the impacts of waste management alternatives on the use of natural resources, and, by implication, the entities (firms) that would be subject to new waste management requirements. If subjected to new regulatory requirements, firms in affected mineral processing sectors will incur compliance costs which will generate both direct and indirect economic impacts. Direct impacts on the company include lower profits and the reduced value of assets because of anticipated reductions in future profits. Indirect impacts are associated with the "pass through" of compliance costs either backwards in the form of lower wages paid to workers and/or lower prices paid to suppliers, or forward in the form of higher prices charged to customers. Additional direct and indirect impacts on the local or national economy are associated with the possibility of plant closures and associated job and income losses, reductions in federal, state, and county tax revenues, possible changes in the U.S. balance of trade, and increased reliance on foreign sources for critical mineral supplies.

EPA's economic impact assessment of prospective requirements has two parts. First, the Agency put the compliance costs for each affected commodity sector into context by comparing them with other cost and sales figures for the sector. The Agency considered compliance costs to be possibly significant and requiring further evaluation if they were greater than or equal to:

- 1 percent of sales and/or value added;
- 5 percent of current capital outlays i.e., sustaining capital (based on capital compliance costs).

The data used to apply these screening tests are based on standard accounting measures of cost and financial performance, and in general were obtained from published sources. Throughout, EPA has conducted its analysis on a facility-specific basis.

When EPA determined that compliance costs for a facility or mineral processing sector exceeded the screening threshold value for at least two of the indices, the Agency examined the competitive position of affected firms within the sector and conditions in relevant input and product markets to assess the ability of affected firms to pass through compliance costs to workers, to suppliers, and to customers, including foreign markets. The Agency based this assessment on information about industry and market trends, buyer and seller concentration, and inter-industry dependencies. Where the possible pass-through of compliance costs was to other sectors of the U.S. economy, they were viewed as transfers of economic impacts or shifts in the "incidence" of compliance costs; where the pass-through was to foreign markets EPA viewed them as potential reductions in U.S. compliance costs and economic impacts.

The following paragraphs describe the data sources that EPA used to characterize the financial performance and industry and market characteristics for each mineral commodity sector. Then, the Agency discusses the methodology for evaluating the significance of compliance costs for each sector and for assessing the most likely distribution of compliance costs across market levels. The sector-specific discussions that follow this chapter provide economic profiles of each affected industrial sector, including information about product markets, input factor markets, and trends in production and consumption.

Data Sources

The U.S. Bureau of Mines provided most of the industry and market data on which EPA has based its assessment of the economic conditions facing each mineral commodity sector. The Minerals Yearbook 1987 and Mineral Commodity Summaries 1989 are the major published sources of data from the Bureau of Mines, but additional BOM data were obtained from contacts with the Bureau's Mineral Commodity Specialists. Data from the Technical Background Document[18] and trade journals, including Chemical & Engineering News, were also used. World Metal Statistics, published by the World Bureau of Metal Statistics, was used to characterize global markets for some mineral commodity sectors.

Methodology

The economic impact analysis was conducted in two steps. The first includes a set of screening indices to test the significance of compliance costs. These indices were based on capital investment requirements and other compliance costs in relation to current costs, sales, and financial performance indicators for each sector. For sectors where the screening analysis suggested potentially significant compliance costs, the Agency further evaluated the nature and incidence of potential economic impacts, including a review of the competitive position of affected facilities within each sector and in relevant input and product markets to determine pass-through potential. Combined, the two parts of the analysis describe the magnitude of economic impacts and the way that they can be expected to spread from regulated mineral processing sectors to other segments of the U.S. economy.

Screening Level Test of Significance The objective of this screening analysis was to determine which affected facilities and mineral commodity sectors might experience significant compliance costs. The screening indices used to determine significance are displayed in Exhibit 2-8. The underlying data used to compute the indices are described in Appendix E-4 to this document, while the results of the ratio analysis are presented in tabular form by commodity sector in Appendix E-5.

In general, if more than two of the screening indices for a given sector were exceeded, EPA assumed that the economic impact on that facility or sector might be significant and evaluated compliance costs in greater depth. Facilities and sectors facing compliance costs below the thresholds were regarded as unlikely to experience significant economic impacts associated with new regulatory requirements. For those sectors with potentially significant compliance costs, EPA then assessed the most likely distribution or "incidence" of economic impacts.

Incidence of Impacts The cost of regulatory compliance is not incurred only by firms in the regulated sector. To prevent plant closures and layoffs, workers may make wage concessions; to prevent supply shortages, customers may pay higher prices (because the affected industries generally produce intermediate products); and to maintain markets, suppliers may accept lower prices for mineral processing inputs. This may cushion the direct impact of compliance costs on the regulated industry and spread them to other segments of the U.S. economy.

In general, the pass-through of compliance costs follows the path of least market resistance. Where all facilities in the affected sector face similar compliance costs and produce commodities for which there are few alternative supply sources or substitute materials, there is a high likelihood that moderate compliance costs can be passed forward in the form of higher product prices. On the other hand, where only a small proportion of facilities in a sector are affected, or alternative supplies or substitute materials are abundant, the opposite may be true. Similar possibilities exist in input and labor markets where the regulated sector may be able to negotiate wage or price concessions in order to remain in operation or continue operating at current levels.

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[18] U.S. EPA. 1989. Technical Background Document -- Development of the Cost, Economic, and Small Business Impacts Arising from the Reinterpretation of the Bevill Exclusion for Mineral Processing Wastes. Economic Analysis Staff, Office of Solid Waste, August 18.

Exhibit 2-8

Indicators of Significant Economic Impact

Screening Index	Symbol	Description
Compliance Costs as Percent of Sales	CC/VOS	Percent by which product price would need to increase to maintain current production and profits with compliance
Compliance Costs as Percent of Value Added	CC/VA	Percent reduction in value added due to outlays for compliance
Capital Investment Requirements as Percent of Current Capital Outlays	IR/K	Percent of current capital expenditures that would need to be diverted to compliance uses if total capital outlay remained constant

In all cases, the ability to pass through compliance costs depends on the initial incidence of compliance costs within the affected sector and the concentration and interdependency of buyers and sellers in relevant input and product markets.

The price sensitivity of buyers and sellers in relevant markets cannot be estimated precisely but enough information is available about industry and market conditions and relevant market trends to assess the most likely distribution of economic impacts. For example, current wages and salary data can give an indication of whether some firms may be able to pass compliance costs back to labor. For purposes of analysis, information about factor and product markets related to each [illegible]cted mineral processing sector has been organized on the basis of the following criteria:

MARKET CONCENTRATION

- Affected sectors as sellers in U.S. and world markets
- Affected sectors as buyers of inputs and labor

INTERINDUSTRY DEPENDENCE

- Availability/cost of alternatives
- Availability/cost of substitutes

INDUSTRY/MARKET TRENDS

- U.S. mineral production and consumption
- Global mineral production and consumption
- U.S. mineral imports and exports

VALUE ADDED

- Contribution of material and processing costs to the price of fabricated/manufactured product

Based on both quantitative and qualitative assessments of the available industry and market information. EPA estimated the most likely incidence of compliance costs across the following market segments:

Segment	Type of Impact
• Regulated Industry	• Lower Profits
• Labor	• Lower Wages/Fewer Jobs
• Supplying Industries	• Lower Input Prices/Smaller Markets
• Intermediate U.S. Product Markets	• Higher Product Prices
• Final U.S. Markets	• Higher Product Prices
• Foreign Markets	• Higher Product Prices

In general, the type of impact in the regulated industry involves higher costs and lower profits, including the possibility of continual negative profits and associated plant closures. The type of impact in other segments involves adverse changes in market prices (higher prices for buyers and lower prices for sellers of mineral processing inputs) and reductions in market size.

The levels of impacts were assessed on the basis of relatively near-term changes in market conditions. For example, the ability of the affected firms to pass-through compliance costs in the form of higher product prices would be shown to mitigate the direct impact of the proposed rule on the regulated industry. The possibility that higher U.S. prices might then attract new foreign competition, increase imports, and eventually result in lower U.S. product prices has not been factored into EPA's analysis.

2.2.6 Summary

Based upon the analysis of the study factors found at §8002(p) as described above, EPA has arrived at preliminary findings that are relevant to the appropriate regulatory status under RCRA of the special wastes from mineral processing. These findings were arrived at through an explicit evaluation process, which is described below. In this process, the Agency considered the study factors in a step-wise fashion, first assessing the need for additional regulatory controls (or absence thereof), then evaluating the options for appropriate requirements that could be applied to each individual waste stream for which additional controls might be in order. In applying this framework, EPA has employed a number of assumptions, which are described in the following paragraph. Each sector-specific chapter in this volume concludes with a summary that highlights the major findings of this study for the waste(s) of interest, organized by the issues presented in sequence below. EPA's preliminary conclusions regarding the appropriate regulatory status of each special mineral processing waste are presented in Volume I of this report.

The first assumption that the Agency has employed is that explicit decision criteria were needed and should be applied uniformly to all of the special study wastes. In this manner, consistent and reasonable decisions regarding the need for additional regulatory controls can be achieved. The second major assumption guiding EPA's decision-making process was that the study factors that are most important in establishing the regulatory status of the special wastes are risks posed and documented damages caused by the wastes, and the costs and impacts that would be associated with more stringent regulatory controls. The reason for this is that in the absence of potential risk and/or documented damages, there is no need for hazardous waste regulation under RCRA Subtitle C (the key issue in question); if greater regulatory controls are needed because of significant potential or documented danger, the costs and impacts of regulatory controls are the critical factor in determining whether a given alternative would lead to the desired outcome (adequate protection of human health and the environment, and continued operation of the affected industries). EPA also believes that it has developed and analyzed regulatory compliance scenarios that are realistic from an operational and engineering standpoint, and that are likely to be adequately protective of human health and the environment, i.e., could be implemented by facility operators and would result in societal benefits. Finally, because the waste management controls that might be imposed under the auspices of Subtitle D or developed under the regulatory flexibility provided by RCRA §3004(x) are not well-defined at this juncture, the focus of EPA's comparisons of the desirability of Subtitle C and Subtitle D regulation has been on the full Subtitle C and Subtitle D-Plus scenarios, rather than on Subtitle C-Minus and baseline conditions. Nonetheless, because of the high volume nature of the special mineral processing wastes, EPA believes that an effective and appropriate regulatory program for the management of these materials should be tailored to reflect their unusual characteristics; the Agency's preliminary assessment of how these programs might be tailored in this way is reflected in the Subtitle C-Minus and Subtitle D-Plus scenarios described in the previous section.

Evaluation Criteria

Step 1. Does management of this waste pose human health/environmental problems? Might current practices cause problems in the future?

Critical to the Agency's decision-making process is whether each special waste either has caused or could cause human health or environmental damage. To resolve this issue, EPA has posed the following key questions:

1. Has the waste, as currently managed, caused documented human health impacts or environmental damage?
2. Does EPA's analysis indicate that the waste could pose significant risk to human health or the environment at any of the sites that generate it (or in off-site use), under either current management practices or plausible mismanagement scenarios?
3. Does the waste exhibit any of the characteristics of hazardous waste?

If the answer to any of these three questions was yes, then EPA concluded that further evaluation was necessary. If the answer to all of these questions was no, then the Agency concluded that regulation of the waste under RCRA Subtitle C is unwarranted.

Step 2. Is more stringent regulation necessary and desirable?

If the waste has caused or may cause human health or environmental impacts, then EPA concluded that an examination of alternative regulatory controls was appropriate. Given the context and purpose of the present study, the Agency focused on an evaluation of the likelihood that such impacts might continue or arise in the absence of Subtitle C regulation, by posing the following three questions:

1. Are current practices adequate to limit contaminant release and associated risk?
2. What is the likelihood of new facilities opening in the future and generating and managing the special waste in a different environmental setting than those examined for this report?
3. Are current federal and state regulatory controls adequate to address the management of the waste?

If current practices and existing regulatory controls are adequate, and if the potential for actual future impacts is low (e.g., facilities in remote locations, low probability of new facilities being constructed), then the Agency tentatively concluded that regulation of the waste under Subtitle C is unwarranted. Otherwise, further examination of regulatory alternatives was necessary.

Step 3. What would be the operational and economic consequences of a decision to regulate a special waste under Subtitle C?

If, based upon the previous two steps, EPA believed that regulation of a waste under Subtitle C might be appropriate, then the Agency evaluated the costs and impacts of two regulatory alternatives that are based upon Subtitle C, and one alternative that reflects one possible approach that might be taken under RCRA Subtitle D. The focus of this inquiry was whether the magnitude and distribution of regulatory compliance costs might jeopardize the continued economic viability of one or more generators if the waste were to be regulated under the Subtitle C regulatory scenario. The key questions in the Agency's decision-making process were as follows:

1. Are predicted economic impacts associated with the Subtitle C scenario significant for any of the affected facilities?
2. Are these impacts substantially greater than those that would be experienced under the Subtitle D-Plus scenario?
3. What is the likely extent to which compliance costs could be passed through to input and/or product markets, i.e., to what extent could regulatory cost burdens be shared?
4. In the event that significant impacts are predicted, might a substantial proportion of domestic capacity or product consumption be affected?
5. What effects would hazardous waste regulation have upon the viability of the beneficial use or recycling of the special waste?

In EPA's judgment, absence of significant impacts or high pass-through potential suggested that Subtitle C regulation might be appropriate for wastes that pose significant risk. In cases in which even relaxed Subtitle C standards would impose widespread and significant impacts on facilities, and/or deter the safe and beneficial use of the waste, EPA concluded that regulation under some form of Subtitle D program might be more appropriate.

Chapter 3
Alumina Production

The domestic alumina production (bauxite refining) industry consists of five facilities that, as of September 1989, were active and reported generating a special waste from mineral processing: red and brown muds from bauxite refining. The information included in this chapter is provided in additional detail in the supporting public docket for this report.

3.1 Industry Overview

Bauxite refineries produce alumina (Al_2O_3), which is used primarily as a feedstock for the aluminum reduction industry. Four of the facilities are operated by major aluminum producers, two by Alcoa, and one each by Reynolds and Kaiser. The fifth facility is operated by Ormet, which produced only about 1 percent of the total reported 1988 alumina production. Kaiser Aluminum is ultimately owned by MAXXAM Inc. of Los Angeles;[1] Ormet, owned by Ohio River Associates in 1988, is currently owned by Oralco Management Services Inc.

The dates of initial operation for these five facilities range from 1952 to 1959, with the individual plants having an average age of approximately 33 years. All of the facilities have undergone modernization, with the first in 1965 and the latest in 1986.[2] The locations and ore sources of the five facilities are presented in Exhibit 3-1. Total annual production capacity for the domestic bauxite refining industry, as reported by the facilities, is approximately 4,900,000 metric tons. For the five facilities, the 1988 average capacity utilization rate was 83.5 percent. Excluding the Ormet facility with an 8.9 percent 1988 annual capacity utilization rate, the rate for the sector is 91.7 percent. The total reported 1988 production of alumina was 4,086,000 metric tons.[3]

Strong demand for primary aluminum and elevated aluminum prices have led to steadily increasing consumption of domestic and imported bauxite and continued increases in alumina production in the U.S. since 1986.[4] In order to meet the growing demand for alumina, bauxite refineries have averaged over 90 percent capacity utilization over the past two years. Recently, expansion in bauxite refining capacity has been focused outside of the U.S. It is likely that this trend will continue in the future, with major capacity additions likely to occur in Canada and the Middle East.[5] In addition, new plants using new technology may have to be built to produce alumina from the numerous non-bauxitic materials, including clay, coal waste, and oil shales, that are good potential sources of alumina.[6] Development of such technology would reduce U.S. dependence on bauxite imports, which comprised approximately 95 percent of the total 1989 U.S. consumption of bauxite.[7]

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[1] MAXXAM Inc. is the parent of MAXXAM Group, Inc., which owns Kaiser Tech Limited, the immediate owner of Kaiser Aluminum and Chemical Corporation.

[2] Alcoa, Kaiser, Ormet, and Reynolds, 1989. Company responses to "National Survey of Solid Wastes from Mineral Processing Facilities," 1989.

[3] Ibid.

[4] Luke H. Baumgardner, U.S. Bureau of Mines, "Bauxite," Mineral Commodity Summaries, 1989 Ed., p. 23.

[5] John W. Moberly, "Aluminum: Capacity Rise Stabilizes Price; 121st Annual Survey and Outlook," E&MJ, March 1990, p. 41.

[6] Patricia A. Plunkert, U.S. Bureau of Mines, "Bauxite," Mineral Commodity Summaries, 1990 Ed., p. 29.

[7] Ibid., p. 28.

Exhibit 3-1
Bauxite Refineries[a]

Owner	Location	Ore Source (1982)
ALCOA	Bauxite, AR[b]	U.S. (Bauxite, AR)[c]
ALCOA	Point Comfort, TX	(Confidential)
Kaiser	Gramercy, LA	Jamaica[d]
ORMET	Burnside, LA	Sierra Leone, Brazil, Guyana[e]
Reynolds	Gregory, TX	Austrailia, Jamaica, Brazil, Guinea[e]

(a) According to BOM sources, VIALCO, an affiliate of Oralco Management Services Inc., plans to restart operation of its Alumina plant at St. Croix, U.S. Virgin Islands.

(b) According to BOM sources, Alcoa announced the permanent closure of its Bauxite, AR, plants on June 7, 1990.

(c) Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics in the Bauxite Refining and Primary Aluminum Industry. Prepared by Radian Corporation for U.S. EPA, Office of Solid Waste, Washington, D.C., November 1984.

(d) Kaiser, 1988. Personal communication with Kaiser representatives.

(e) Bureau of Mines commodity specialist, June 27, 1990.

The production of alumina from bauxite ore generally follows five steps, as shown in Exhibit 3-2.[8] First, the bauxite ore is crushed and screened, and then mixed with a caustic alkaline solution (NaOH). The slurried ore is then routed to digesters, where the aluminum is heated and solubilized as sodium aluminate ($Na_2Al_2O_3$). In the third step, the solution is cooled (from nearly 500°F to about 200°F) and purified. Sand (particles above 100 microns) is removed in a settling tank or cyclone and sent to disposal. Iron oxide, silica, and other undigested portions of the ore (i.e., the special waste, known collectively as red mud) are also removed in settling, thickening, and filtration units, and sent to treatment and disposal units. The fourth refining step is the precipitation of the cooled and purified aluminum hydroxide using sodium hydroxide seed crystals. The precipitate is filtered, then concentrated by evaporation; the resulting intermediate product is a hydroxide filter cake. The fifth and final step is the calcination of the hydroxide filter cake to produce anhydrous alumina. If hydrate is the desired final product, the hydroxide filter cake may be dried at lower temperatures than those employed for calcining.

3.2 Waste Characteristics, Generation, and Current Management Practices

Red and brown muds are precipitated from a caustic suspension of sodium aluminate in a slurry and routed to large on-site surface impoundments known as red and brown mud lakes. In these lakes, the red and brown muds settle to the bottom and the water is removed, treated, and either discharged or reused. The muds are not removed, but are accumulated and disposed in place. The muds dry to a solid with a very fine particle size (sometimes less than 1 μm).

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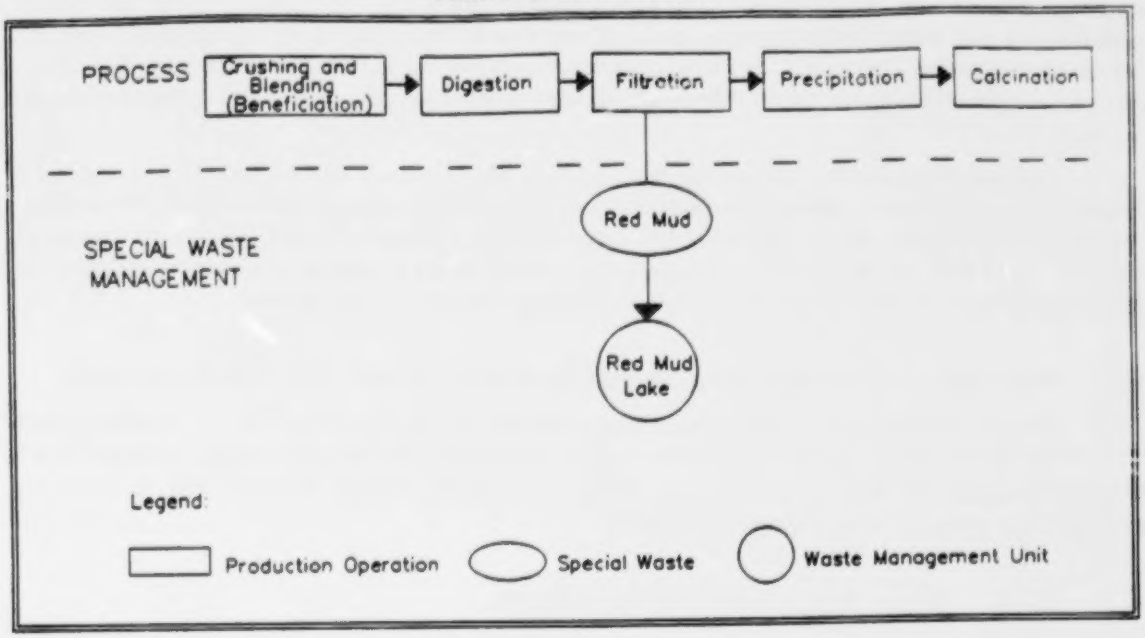
[8] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics in the Bauxite Refining and Primary Aluminum Industry. Prepared by Radian Corporation for U.S. EPA, Office of Solid Waste, Washington, D.C., November 1984.

Exhibit 3-2
Alumina Production



Red muds from bauxite refining are generated at four facilities[9] The fifth facility, Alcoa in Bauxite, Arkansas, generates a residual that is different in color and is commonly called brown mud. The only difference in the operations generating the two varieties of mud is that red muds at Alcoa/Bauxite are sintered and leached to recover additional sodium aluminate, which changes the color of the material but does not substantially change the chemical characteristics of the waste. Therefore, for purposes of this report, the waste generated at all five facilities, including the brown muds, will be referred to as red muds.

Red muds contain significant amounts of iron (20 to 50 percent), aluminum (20 to 30 percent), silicon (10 to 20 percent), calcium (10 to 30 percent), and sodium (10 to 20 percent). Red muds may also contain trace amounts of elements such as barium, boron, cadmium, chromium, cobalt, gallium, vanadium, scandium, and lead, as well as radionuclides. The types and concentrations of minerals present in the muds depend on the composition of the ore and the operating conditions in the digesters.

Using available data on the composition of red muds, EPA evaluated whether this waste exhibits any of the four hazardous waste characteristics: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Data are available on the concentrations of all eight inorganic EP constituents in four samples of red muds from three of the five facilities of interest. Based on available information and professional judgment, EPA does not believe that red muds exhibit any of the characteristics of hazardous waste. In fact, the concentrations of all EP constituents (except selenium) in the leachate are at least two orders of magnitude below the EP regulatory levels; the maximum concentration of selenium in the EP extract is approximately 0.3 times the EP regulatory level.

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[9] In the April 17, 1989 proposal to reinterpret the scope of the mining waste exclusion, EPA indicated that it "considers pisolites to be a component of red muds" (54 FR 15335). In the final rule (see 54 FR 36592, September 1, 1989), however, the scope of beneficiation activities was revised such that pisolites are considered a waste from beneficiation rather than processing. Consequently, pisolites are not within the scope of this report.

Non-confidential waste generation rate data were reported for red muds by all five bauxite refining facilities. The aggregate industry-wide generation of red mud wastes by the five facilities was approximately 2.8 million metric tons in 1988, yielding a facility average of nearly 564,000 metric tons per year. Reported annual generation rates ranged from 26,000 to 1.2 million metric tons per facility, though the facility generating the least waste, Ormet/Burnside, produced very little alumina, accounting for only about 1 percent of domestic production. The next lowest reported annual generation rate was 190,000 metric tons. The sector-wide waste-to-product ratio was 0.69 in 1988; waste-to-product ratios for individual facilities ranged from 0.40 to 1.05.

The impoundments that receive the muds typically have a surface area of between 44.6 and 105.3 hectares (110 and 260 acres), although one impoundment is 10.1 hectares and another is almost 1,300 hectares. The depth of the impoundments range from 1 to 16 meters (3 to 52 feet), with an impoundment average of 7 meters. As of 1988, the quantity of muds accumulated on-site at the 5 facilities ranged from 500,000 to 22 million metric tons per facility, with an average of 9.7 million metric tons per facility.

3.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment: and (2) documented cases in which danger to human health or the environment has been proved. Overall findings regarding the hazards associated with red muds are provided after these two study factors are discussed.

3.3.1 Risks Associated with Red Muds

Any potential danger to human health and the environment from red muds depends on the presence of toxic constituents in the muds that may pose a risk and the potential for exposure to these constituents.

Constituents of Potential Concern

EPA identified chemical constituents in red muds that may pose a risk by collecting data on the composition of the waste and evaluating the intrinsic hazard of the mud's chemical constituents.

Data on Red Mud Composition

Data on the composition of red muds are available from industry responses to a RCRA §3007 request in 1989, a 1985 sampling and analysis effort by EPA's Office of Solid Waste (OSW),[10] and a 1982 study by EPA's Office of Radiation Programs (ORP).[11] These data identify the concentrations of 13 metals, 7 radionuclides, and 5 anions (fluoride, phosphate, chloride, nitrate, and sulfate) in the mud solids and/or leachate from all 5 facilities that currently generate the muds. Data are only available from EP (not SPLP) leach tests.

Although the data from most of these sources and facilities are generally consistent, there is considerable variability for several constituents. Specifically, reported concentrations of arsenic, chromium, copper, iron, manganese, selenium, and zinc in the mud solids vary by an order of magnitude across facilities, with the concentrations usually being lowest at one facility (which requested that its concentration data be treated as confidential). Similarly, reported concentrations of chromium, fluoride, selenium, and chloride in the mud leachate also vary by an order of magnitude across facilities.

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[10] Environmental Protection Agency, 1985. Overview of Solid Waste Generation, Management, and Chemical Characteristics in the Bauxite Refining and Primary Aluminum Reduction Industries, Office of Solid Waste, p. B-1 and B-2.

[11] Environmental Protection Agency, 1982. Emissions of Naturally Occurring Radioactivity from Aluminum and Copper Facilities, Office of Radiation Programs, Las Vegas Facility, NV, p. 8.

As noted above in Section 3.2, the available data indicate that red muds do not exhibit any of the four characteristics of hazardous waste. Nevertheless, EPA further evaluated the potential for red muds to pose a danger to human health or the environment, as described below.

Process for Identifying Constituents of Potential Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the red muds data to determine if the mud or mud leachate contain any constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing the concentrations of each constituent to screening criteria and then by evaluating the environmental persistence and mobility of any constituents present in concentrations that exceed the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which red mud constituents are released to the environment and migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic organisms, and water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of the hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Of the 25 constituents analyzed in mud solids, only 3 were determined to be present in the muds in concentrations that exceed the screening criteria.

- Arsenic concentrations in one out of two samples collected from two facilities exceed the chronic ingestion and inhalation screening criteria, by a factor of four. Exceedance of the ingestion criterion suggests that arsenic could pose a cancer risk of greater than 10^{-5} if the muds are incidentally ingested on a routine basis (which could only occur if access to mud impoundments after closure is not restricted and people come into direct contact with the dried muds). Exceedance of the inhalation criterion suggests that, if dust from the muds is blown into the air in a concentration that equals the maximum allowable limit (the National Ambient Air Quality Standard) for particulate matter, chronic inhalation of arsenic could pose a cancer risk greater than 10^{-5}. As discussed in the next section, such large exposures to windblown dust are generally not expected.

- Chromium concentrations in both samples (one each from two facilities) exceed the chronic inhalation screening criterion by as much as a factor of 22. This suggests that if dust from the muds is blown into the air in a concentration that equals the National Ambient Air Quality Standard for particulate matter, chronic inhalation of chromium could cause a cancer risk exceeding 10^{-5}. Again, EPA generally does not expect such large exposures, as explained in the next section.

- Radium-226 concentrations in the mud solids exceed the radiation protection screening criterion by a factor of 1.3. This suggests that red muds could pose a slight radiation risk if they are used in an unrestricted manner (e.g., direct radiation and radon exposures if people were allowed to build homes on the closed impoundment areas).

In addition to these three constituents, the alkaline nature (i.e., high pH) of the muds will limit plant growth on the dried, closed impoundments. Data from EPA's Office of Water show that the supernatant removed from the red mud impoundments has a pH of roughly 11.6.[12] The residual alkali content of the muds that are left in the impoundments makes it difficult to use these impoundment areas for agricultural production.[13]

Of the 18 constituents analyzed in leachate from red muds, only two constituents are present in concentrations that exceed the initial screening criteria. Arsenic concentrations in the leachate exceed the health screening criterion in two out of four samples (from two out of three facilities). The maximum recorded arsenic concentration exceeded the screening criterion by only a factor of three. This suggests that, if the leachate is released to ground water and diluted by only a factor of 10, the resulting concentration of arsenic may pose a cancer risk exceeding 10^{-5} if ingested. The concentration of selenium in the leachate exceeds the water resource damage criterion in one out of four samples (from one out of three facilities). The one high selenium concentration exceeds the criterion by only a factor of three. This suggests that, if the leachate is released to ground water and diluted by a factor of 10 or less, the downgradient concentrations of selenium may exceed the drinking water maximum contaminant level (MCL) for that constituent. While these concentrations of arsenic and selenium exceed the conservative screening criteria, they do not exceed the EP toxicity regulatory levels.

These exceedances of the screening criteria, by themselves, do not demonstrate that the muds pose a significant risk, but rather indicate that the muds could pose a risk under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the muds to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the waste.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of red muds as they are managed in impoundments at the five bauxite refining facilities. It does not assess the hazards of off-site use or disposal of the muds because the muds are currently managed only on-site and are not likely to be managed off-site in the near future. In addition, the following analysis does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on future conditions. Alternative practices for the management of the muds are discussed in Section 3.5.

Ground-Water Release, Transport, and Exposure Potential

During the operating phase of the red mud lakes, the muds are usually submerged beneath a liquid that can serve as a leaching medium, potentially transporting contaminants to underlying ground water. After the lakes are closed, the liquids are evaporated or removed, and the potential for leaching becomes highly dependent on the extent to which precipitation infiltrates through the mud and into the ground. Based on the leach test data analyzed above, arsenic and selenium are the constituents in red muds that are most likely to leach from the muds in concentrations that exceed the screening criteria. Both arsenic and selenium are persistent and relatively mobile in ground water, and therefore are capable of migrating readily if released.

The potential for leachate from the muds to be released to ground water and cause impacts through that pathway varies according to site-specific conditions, as summarized below:

- At the Burnside, LA facility, the mud impoundment is underlain by recompacted local clay. Ground water is very shallow (only 2 meters below the land surface) and the base of the impoundment extends below the water table. The uppermost useable aquifer, however, appears to be separated from the base of the impoundment by a distance of roughly 30 meters. The nearest drinking water well appears to be located 90 meters downgradient.

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[12] Environmental Protection Agency, 1984. Development Document for Effluent Limitations Guidelines and Standards, Office of Water, p. 56.

[13] W.A. Anderson and W.E. Haupin, 1978. Bauxite Refining, Aluminum Company of America, Kirk-Othmer Encyclopedia of Chemical Technology, John Wiley and Sons, NY, p. 142.

- The conditions at the Gramercy, LA facility are similar to those at the Burnside facility. The only differences are that the impoundments at Gramercy are equipped with a leachate collection system and the nearest drinking water well at Gramercy is farther away, approximately 800 meters downgradient. As discussed in the damage case section of this chapter, elevated concentrations of chloride have been detected in ground water beneath the impoundments. However, the muds do not appear to be an important contributor to this contamination because, based on the Agency's leach test analyses, chloride is a minor constituent of the mud leachate (the maximum chloride concentration measured in the mud leachate was less than one-quarter of the conservative screening criterion).

- The impoundment at the Bauxite, AR facility is underlain by in-situ clay and is equipped with a leachate collection system and bentonite slurry walls. The base of the impoundment appears to be separated from shallow ground water by 15 meters and the uppermost useable aquifer by roughly 30 meters. The earth material separating the impoundment from this useable aquifer is an igneous rock. Ground water in the area of the site is used as a rural domestic water supply, and the nearest drinking water well appears to be located 300 meters downgradient.

- At the Point Comfort, TX facility, the mud impoundment is underlain by in-situ clay, but is not equipped with any other controls. Because the impoundment is 16 meters deep and shallow ground water exists at a depth of 5 meters, the base of the impoundment extends below the water table. The uppermost useable aquifer, however, is over 400 meters below the land surface. This deep aquifer is used as a municipal and commercial/industrial water supply, and the nearest drinking water well appears to be located 1,300 meters downgradient.

- The impoundments at the Gregory, TX facility are underlain by in-situ clay. As for most of the other sites, ground water is shallow and the base of the impoundment extends below the water table. Neither the shallow ground water nor water at greater depths, however, is used for water supply purposes, according to facility personnel.

In summary, laboratory leaching tests show that arsenic and selenium may leach from red muds in concentrations that exceed the screening criteria. Concentrations of these and other constituents under field conditions are, however, expected to be lower due to the alkaline nature of the waste. While the potential for release of constituents to ground water is limited by some type of management controls employed at each site, the bases of most impoundments do extend into the saturated zone and shallow ground-water contamination is therefore possible. However, downward migration of this contamination to useable aquifers is less likely, especially at the Bauxite and Point Comfort facilities, because of hydrogeological conditions. Considering the low concentrations of contaminants in the leachate and the potential locations of drinking water wells near these facilities, the concentrations of any contaminants that migrate into the deeper useable aquifers at the five facilities is expected to be below levels of concern at existing downgradient exposure points.

Surface Water Release, Transport, and Exposure Potential

Constituents of potential concern in the red muds could, in theory, enter surface waters by migration of leachate through ground water that discharges to surface water, or by direct overland (storm water) run-off of dissolved or suspended constituents. As discussed above, only arsenic and selenium are expected to leach from the muds in concentrations above the screening criteria, but even these concentrations are relatively low and are likely to be diluted below levels of concern in all but very small streams. There were no constituents detected in the mud leachate in concentrations that appeared to present a potential threat to aquatic organisms; the arsenic and selenium concentrations are of possible concern from only a health risk standpoint.

The high alkalinity of the muds, however, could result in leaching of alkaline water. If the receiving water is not well-buffered, its pH could exceed levels that are protective of aquatic life. Alkaline water also can have low resource value due to its corrosive properties.

The potential for mud contaminants to migrate into surface water and cause impacts is site-specific based on a number of factors as summarized below:

- At the Burnside facility in Louisiana, the red mud impoundment is equipped with run-on/run-off controls to limit the direct overland flow of mud contaminants, but there are no controls (e.g., liner, leachate collection system, or slurry wall) to prevent contaminants from seeping into surface water via ground water. The facility is only 15 meters from the Panama Canal which feeds into the Blind River. While the Blind River has a moderate to large dilution capacity (the annual average flow is 302 mgd), the Panama Canal's flow is small and cannot readily assimilate large contaminant loads. As discussed in the damage case section of this report, excess process water that has accumulated in red mud impoundments at the site during heavy rainfall events has been discharged to the canal, resulting in high pH excursions. These discharges have occurred only in emergency situations, and the pH excursions appear to be caused by the supernatant liquid discharged from the impoundments, not the muds themselves.
- At the Point Comfort facility in Texas, the on-site impoundment is equipped with run-on/run-off controls, but there are no controls to limit seepage of contaminants via ground water. The facility is located only 15 meters from Lavaca Bay, which contains saltwater. Water in the bay is not used for human consumption, but is withdrawn at a point 270 meters downstream and used for livestock watering.
- On-site impoundments at the Gramercy Works in Louisiana are equipped with run-on/run-off controls and a leachate collection system. The facility is located roughly 110 meters from the Blind River, which has a moderate to large dilution capacity (it is the same river that is near the Burnside facility). Water is withdrawn from the river for human consumption at a point 4,900 meters downstream, but water is not withdrawn for any other uses within 24 km (15 miles).
- The impoundment at the facility in Gregory, Texas is equipped with run-on/run-off controls. The facility is located roughly 60 meters from the Corpus Christi Bay, which contains saltwater that is not used for drinking or any other consumptive use within 24 km (15 miles).
- At the facility in Bauxite, Arkansas, the impoundment is equipped with run-on/run-off controls, a leachate collection system, and a bentonite slurry wall. The facility is located about 300 meters from Hurricane Creek, which has a moderate dilution capacity (its annual average flow is 80 mgd). Water is withdrawn from this creek for human consumption at a point 7 km downstream, but water is not withdrawn for any other uses within 24 km (15 miles).

In summary, the potential for direct overland flow of red mud contaminants to surface water is limited at all five facilities by the use of run-on/run-off controls. Migration into surface water via ground-water seepage, however, may occur at three facilities (at Burnside, Point Comfort, and Gregory) that are close to surface water bodies and do not employ any measures to control leachate migration. (The potential for ground-water contamination to seep into surface water at the other facilities is smaller because of the use of leachate migration controls and the greater distance to surface waters.) Because of the distances to drinking water intakes, the moderate to high flows of the nearby water bodies, and the low concentrations of contaminants expected in the mud leachate, any surface water contamination at the three facilities caused by the muds would probably not pose a health threat. In addition, any migration of mud contaminants into surface water is not likely to pose an ecological threat at any facility because, based on the Agency's leach tests, contaminants do not appear to leach from the muds in concentrations that are potentially harmful to aquatic organisms. While the pH of the leachate could be high, pH excursions in surface waters are more likely to be caused by periodic direct discharges, not the low-level chronic loads that are expected through ground-water discharges.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern are nonvolatile inorganics, red mud contaminants can only be released to air in the form of windblown dust. During the operating phase of the impoundments, the potential for dusting from the muds is virtually non-existent because the muds are submerged beneath liquids. When the impoundments are closed and the muds have dried, there is a potential for particles of the mud to be released to air (none of the facilities practice any dust suppression/control measures). This is especially true at the facilities in arid areas (Gregory and Point Comfort, Texas) where the muds are less likely to remain moist due to precipitation. The muds dry to a very fine particle size (sometimes less than 1 micrometer) which is highly susceptible to wind erosion. Based on sample analyses of the muds, the only constituents that could pose a threat through the inhalation pathway are arsenic and chromium, and this would only be a threat if dust particles are released from dried impoundments in a high concentration (that equals or exceeds the National Ambient Air Quality Standard for particulate matter). The nearest residence at the Gregory facility is 120 meters away, and the nearest residence at the Point Comfort facility is roughly 400 meters away. Considering these distances and the relatively low concentration of contaminants in the muds, airborne concentrations of arsenic and chromium at the existing residences closest to these facilities are likely to be below levels of concern. Dust could be a problem at these facilities, however, if people were allowed to come into close contact with the muds after closure.

Proximity to Sensitive Environments

None of the bauxite refining facilities within the scope of this analysis are located in or within one mile of karst terrane, a fault zone, the habitat of an endangered species, a National Park, a National Forest, or a National Wildlife refuge. In addition, none of the facilities are located in a wetland, although two facilities are located within one mile of wetlands.

Risk Modeling

Based upon the evaluation of intrinsic hazard and the analysis of factors that influence risk presented above, and upon a comprehensive review of information on documented damage cases (presented in the next section), EPA has concluded that the potential for red muds to impose significant risk to human health or the environment if managed according to current practice is low. Therefore, the Agency has not conducted a quantitative risk modeling exercise for this waste. (See sections 3.3.3 and 3.7 below for further discussion.)

3.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the performance of waste management practices for red muds from bauxite refining at the five active facilities and at one inactive bauxite facility.[14] The inactive facility was the Alcoa plant in Bayden, North Carolina. The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found documented environmental damages associated with red mud discharges to surface water at one facility: Ormet in Burnside, Louisiana. EPA also found evidence of ground-water contamination at the Gramercy, Louisiana facility, but this appears to be associated with brine muds that are not within the scope of this study.[15]

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[14] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

[15] This facility generates brine muds that result from the purification of raw brine (solution mined from Sorrento, Louisiana salt domes) for use in the production of caustic and chlorine.

Ormet in Burnside, Louisiana

Ormet Corporation's Aluminum plant is located south of Baton Rouge in Burnside, on LA Highway 22. The facility is situated near the Mississippi River. The processing unit generating red muds has been operational since 1958.[16]

The facility contains four red mud lakes, referred to as Nos. 1, 2, 3, and 4. These impoundments have a combined surface area of 85 hectares (210 acres).[17] Impoundments Nos. 1 and 2 have been inactive since 1984. Impoundment 4 is the most recently constructed of the 4 pits.[18]

During heavy rainfall events when excess water has accumulated in closed red mud impoundments 1 and 2, Ormet has discharged to a tributary of the "Panama Canal" on an emergency basis.[19,20] The Panama Canal flows from east to west along the northern boundary of the facility, through residential areas, and is a source of domestic water in some cases.[21,22]

Discharge of excess waters has resulted in high pH excursions in some cases. For example, excess water was discharged to the Panama Canal between May 23 and May 27, 1983. Due to improper operation of the neutralization station, combined with communications problems, high pH excursions were not detected until after the discharge event. The excessive pH levels ranged from 9.4 to 10.2 for 4.5 hours on May 23, 1983, and from 9.7 to 9.8 for 7.5 hours on May 24, 1983.[23]

Ormet has stated that "the Panama Canal cannot readily assimilate the discharge of excess rainwater from the Red Mud Impoundments." Ormet goes on to state that "flow in the Panama Canal stops on some occasions, and on others actually flows backward because of wind or tidal action."[24] The Louisiana Department of Environmental Quality (LADEQ) raised concern over the impact of these discharges on the Panama Canal, and requested that Ormet look into the option of discharging to the Mississippi River.[25] The emergency discharges to the Panama Canal have imparted a red color to the canal water, resulting in complaints from local residents.[26,27] Investigation into this phenomenon led LADEQ to conclude that the problem was primarily aesthetic, and no formal action was taken.[28] However, LADEQ did contact Ormet about "ameliorating the conditions in the Panama Canal."[29]

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[16] Ormet. 1989. National Survey on Solid Wastes from Mineral Processing Facilities (File # 347). 4/5/89.

[17] Ibid.

[18] EPA Region 6. 1984. Potential Hazardous Waste Site - Site Inspection Report. 9/5/84.

[19] Ormet. 1983. Letter from F.G. Sikes to 1) M.O. Knudson, EPA Region 6 Water Management Division; and 2) J.D. Givens, LADNR Water Pollution Control Division, Re: None (pH excursions on 5/23 and 5/24/83). 6/2/83.

[20] Ormet. 1985. Letter from F.G. Sikes to G. Aydell, Office of Water Resources, LADEQ, Re: None (Ormet's progress toward ameliorating conditions in Panama Canal). 12/20/85.

[21] Ormet. 1971. Map of Waste Water Discharge into Panama Canal, Burnside, LA. 5/11/71.

[22] Ormet. 1986. Letter from F.D. Sikes to K. Huffman, EPA Region 6 Industrial Permits Section, Re: NPDES Permit No. LA0005606. 6/9/86.

[23] Ormet. 1983. Letter from F.G. Sikes to 1) M.O. Knudson, EPA Region 6 Water Management Division; and 2) J.D. Givens, LADNR Water Pollution Control Division, Re: None (pH excursions on 5/23 and 5/24/83). 6/2/83.

[24] Ormet. 1986. Letter from F.D. Sikes to K. Huffman, EPA Region 6 Industrial Permits Section, Re: NPDES Permit No. LA0005606. 6/9/86.

[25] Ormet. 1985. Letter from F.G. Sikes to G. Aydell, Office of Water Resources, LADEQ, Re: None (Ormet's progress toward ameliorating conditions in Panama Canal). 12/20/85.

[26] Louisiana Department of Natural Resources. 1985. Division of Water Pollution Control Complaint Form, Re: Discharges from Ormet Corp. 2/8/85.

[27] Ormet. 1986. Letter from F.D. Sikes to K. Huffman, EPA Region 6 Industrial Permits Section, Re: NPDES Permit No. LA0005606. 6/9/86.

In 1987, LADEQ's Ground Water Protection Division expressed concern that Ormet's proposal to close the red mud impoundments in their present condition would allow production of leachate and possible ground-water contamination. LADEQ also suggested continued ground-water monitoring as a part of closure.[30] Ground-water monitoring data were not found in the documents reviewed.

3.3.3 Findings Concerning the Hazards of Red muds

Potential danger from red muds is low primarily because the intrinsic hazard of the waste due to the presence of toxic constituents is relatively low. Specifically, the waste does not exhibit any characteristics of hazardous waste (see 40 CFR 261) and only arsenic and chromium are present in sufficient concentrations in the mud solids that could conceivably pose a cancer risk greater than 10^{-5} under conservative ("worst case") exposure scenarios (i.e., routine incidental ingestion of the muds, inhalation of airborne particulate concentrations at the National Ambient Air Quality Standard). The radium-226 concentration is approximately equal to EPA's standard for the cleanup of inactive uranium mill tailings sites, indicating a minor potential for radiation risk if the material were used in home construction (which it is not), or if the mud lakes after closure are allowed to be used in an unrestricted manner. Given current management practices, these exposure scenarios are unlikely. After closure, however, direct access to the muds should be restricted and dust could be a problem at some facilities due to the small particle size of the material and the relatively arid setting of some facilities.

Available laboratory (EP) leachate data indicate that only arsenic (in two out of four samples from two out of three facilities sampled) and selenium (in one sample) are present in leachate from the muds at concentrations that exceed the conservative screening criteria by a narrow margin (a factor of three). Qualitative review of the potential for transport and exposure in ground and surface water indicates that the potential exists at several facilities for mud contaminants to migrate into the environment; however, the migration is not expected to cause significant health or environmental impacts for the reasons stated above. In addition, it is likely that actual leachate concentrations are lower than the laboratory leachate considered here because the EP leaching procedure may overestimate leachate concentrations due to the use of an acidic leaching solution for what is a very alkaline waste material.

The finding that the potential for danger to health and the environment is generally low is consistent with the fact that only very limited documented damages were identified. No documented damages to ground water associated with red muds were identified. At one facility, emergency surface water discharges with a pH > 9 from red mud lakes have occurred as the result of a storm event.

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[28] Louisiana Department of Environmental Quality (LADEQ). 1985. Letter from P.L. Norton, Office of Water Resources, to W.A. Fontenot, LA Dept. of Justice, Lands and Natural Resources Division, Re: None (Red water complaint in the Panama Canal). 3/28/85.

[29] LADEQ. 1985. Letter from G.R. Aydell, Office of Water Resources, to F.G. Sikes, Ormet Corp., Re: None (red color imparted to Panama Canal). 6/27/85.

[30] LADEQ. 1987. Office of Solid and Hazardous Waste, Memorandum from G.H. Cramer to P. Miller, Solid Waste Division, Re: Comments Concerning Ormet Closure GD-005-1484, Ascension Parish. 10/28/87.

3.4 Existing Federal and State Waste Management Controls

3.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations" which provide the basis for minimum requirements of NPDES permits, must be established for various classes of industrial discharges, which include a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT and BAT requirements for bauxite refining specify that there shall be no discharge of process wastewater pollutants to navigable waters (40 CFR 421.10-16), except that discharge is permitted in months in which precipitation exceeds evaporation. Wastewater quality limits for such discharges are not established by the regulations. In the case of States which have not been delegated authority by EPA to manage the NPDES program, such as Texas and Louisiana, EPA includes permit limits necessary to achieve State water quality standards for the effluent discharges.

EPA is unaware of any other specific Federal management control or pollutant release requirements that apply specifically to bauxite red mud wastes.

3.4.2 State Regulation

The five facilities in the alumina sector are located in Arkansas, Louisiana, and Texas. Two of these states, Louisiana and Texas, were chosen for regulatory review for the purposes of this report (see Chapter 2 for a discussion of the methodology used to select states for detailed regulatory study). Both of the study states exclude mineral processing wastes from hazardous waste regulation, classify red muds from alumina production as industrial solid wastes, and have air quality regulations or standards that apply to red mud management and disposal activities.

Of the two study states, Louisiana appears to be most comprehensive in its coverage of red muds from alumina production. Although no requirements have been drafted specifically for red mud impoundments, facility owner/operators must comply with general solid waste disposal provisions for soils (e.g., stability, permeability), hydrologic characteristics, precipitation run-on and run-off, location standards, security, safety, and waste characterization. Moreover, both alumina facilities in Louisiana maintain surface impoundment permits for their red mud impoundments, and must meet general industrial waste surface impoundment requirements such as run-on controls, liner requirements, design standards (e.g., to prevent overtopping and minimize erosion), waste characterization, and ground-water monitoring requirements. Surface impoundments must be dewatered and clean-closed (i.e., all residuals removed) or closed according to solid waste landfill closure provisions. Louisiana also requires that owners/operators of all industrial solid waste landfills and surface impoundments maintain financial responsibility for the closure and post-closure care of those waste units. Although Louisiana does not have an approved NPDES program, the state does require state permits for the discharge of leachate or run-off to surface waters. Finally, Louisiana air regulations require that its alumina processing facilities manage their wastes in a manner necessary to minimize fugitive dust emissions.

As with Louisiana, Texas classifies mineral processing wastes, including red muds from the production of alumina, as industrial solid wastes. Because both alumina facilities in Texas dispose of their wastes on property that is both within 50 miles of the respective facility and controlled by the facility owner/operator, the state has not required either facility to obtain a solid waste disposal permit. Both facilities have notified the state of their waste disposal activities. Facilities discharging to surface water must obtain both Federal NPDES and Texas water quality permits. According to Texas officials, the Reynolds alumina facility does not discharge to surface water and thus does not maintain a NPDES or state discharge permit. Finally, Texas officials noted past problems with fugitive dust emissions from the red mud disposal units at both facilities and indicated that enforcement actions have been taken against the Reynolds facility. The Reynolds facility now uses a flooding process to keep the muds completely under water, while the Alcoa facility places coarse river sand over red mud areas that become dry in order to control emissions.

In summary, the alumina sector states studied in detail for this report, Louisiana and Texas, classify and regulate red muds from the production of alumina as industrial solid wastes. Of the two states, Louisiana has been more comprehensive in the kinds of environmental controls imposed on the management and disposal of these red muds under their solid waste authorities. Both Louisiana and Texas also require State water quality permits for discharges to surface water, in addition to Federal NPDES requirements, and have air quality regulations that address fugitive dust emissions. Texas in particular has had problems with fugitive dust emissions at both of its alumina facilities and has taken action in order to ensure that such emissions are controlled.

3.5 Waste Management Alternatives and Potential Utilization

As noted above, the available data indicate that red muds do not exhibit any of the characteristics of hazardous waste. Consequently, the issue of how alumina producers might modify their operations or waste management practices or be stimulated to develop alternative uses for red muds in response to prospective hazardous waste regulation is moot. Nevertheless, this section provides a brief summary of current red mud waste management practices and potential areas of utilization.

Responses by bauxite processors nationwide to the SWMPF Survey indicate that none of the red mud was sold or used for commercial purposes in the United States in 1988. Although red muds are not currently being utilized efforts have been made to find commercial uses for these residues. Several processes have been developed to recover iron from the red mud residues,[31,32] and the potential exists to use red muds as a raw material in the iron and steel industry.[33] Alumina and titanium dioxide recovery from bauxite muds is also technically feasible, as well as recovery of other rare metals such as gallium, vanadium, and scandium.[34] Processing for recovery of metals other than iron, however, is not economically viable at present.

In addition to metal recovery, other methods of potential utilization of bauxite muds include use in making construction blocks, bricks, portland cement, in lightweight aggregate to make concrete, in plastic and resin as filler, pigments, and applications in making ceramic products.[35,36,37] Research has also been conducted on the potential use of red muds as a reagent in various proposed waste treatment processes.[38,39]

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[31] Parekh, B.K. and W.M. Goldberger. Utilization of Bayer Process Muds: Problems and Possibilities. Proceedings of the Sixth Mineral Waste Utilization Symposium, Chicago, IL, ed. Eugene Aleshin, 2-3 May 1978, pp. 123-132.

[32] Shamsuddin, M. Metal Recovery form Scrap and Waste. Journal of Metals, February, 1986, pp. 29-30.

[33] Steel from Aluminum Waste: The Grate Electric Process Using "Red Mud" as Iron Ore, Heat Engineering, April/June 49:2, 1979, p. 23.

[34] Parekh, B.K. and W.M. Goldberger, op. cit., pp. 123-124.

[35] Parekh, B.K. and W.M. Goldberger. Utilization of Bayer Process Muds: Problems and Possibilities. Proceedings of the Sixth Mineral Waste Utilization Symposium, Chicago, IL, ed. Eugene Aleshin, 2-3 May 1978, pp. 123-132.

[36] Miller, R.H. and R.J. Collins. Waste Material as Potential Replacements for Highway Aggregates. National Cooperative Highway Research Program Report 166, 1976, p. 50.

[37] Thokur, R.S. and B.R. Sant. Utilization of Red Mud: Part I - Analysis and Utilization as Raw Material for Adsorbents, Building Materials, Catalysts, Fillers, Paints and Pigments. Journal of Scientific and Industrial Research, Vol. 42, February 1983, pp. 101-105.

[38] Parekh, and Goldberger, op. cit.

[39] Thokur, and Sant, op. cit.

3.6 Cost and Economic Impacts

Because the available data indicate that red muds do not exhibit any of the characteristics of hazardous waste, the issues of how waste management costs might change because of new requirements associated with hazardous waste regulation under RCRA Subtitle C and what impacts such costs might impose upon affected facilities are not meaningful. Consequently, no incremental costs or associated economic impacts would result from a decision to remove red muds from the Mining Waste Exclusion.

3.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For the special waste in question (red muds), these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of red muds is relatively low compared to the other mineral processing wastes studied in this report. The muds do not exhibit any of the four characteristics of hazardous waste, and only chromium was detected in the muds in a concentration that exceeds the risk screening criteria used in this analysis by a factor of 10. The concentration of radium-226 in the muds approximately equals EPA's standard for the cleanup of inactive uranium mill tailings sites, indicating a slight potential for radiation risk if the muds were used in home construction (which they are not), or if the mud lakes after closure were allowed to be used in an unrestricted manner. In addition, the alkaline nature (i.e., high pH) of the muds is expected to limit plant growth on the dried, closed impoundments.

Based on an examination of the existing conditions at the five active bauxite refining facilities, EPA concludes that the management of red muds may allow contaminants to migrate into the environment, but that the potential for significant exposure to these contaminants is low. Specifically:

- There is a potential for contaminants to migrate into shallow ground water because the muds are managed in impoundments and are submerged below liquids that may drive contaminants to the subsurface, the bases of most impoundments used to manage the muds extend beneath the water table, and only two impoundments are equipped with leachate collection systems. However, useable ground water at each site is considerably deeper (and thus more protected) and the concentration of any released contaminants is expected to be below levels of concern at possible downgradient exposure points.
- It is also possible for contaminants from the impoundments to migrate into nearby surface waters at three facilities that are within 60 meters of a water body. However, this migration is not expected to cause significant impacts because the potential receiving water bodies have a moderate to large assimilative capacity and resulting contaminant concentrations are likely to be well below human health and ecological protection benchmarks.
- When the impoundments have closed and the muds have dried, there is also a potential for fine particles of the mud to be blown into the air as dust. Considering the distances to existing residences and the low concentrations of contaminants in the muds, however, airborne concentrations at the residences are likely to be below levels of concern.

The finding that the potential for danger to human health and the environment is low is consistent with the fact that only one very limited documented damage case attributable to the muds has been identified. State and EPA Regional files were reviewed in an effort to document the performance of red mud management practices at the five active bauxite facilities and at one inactive facility. No documented damages to ground water associated with red muds were identified. At one facility, emergency surface water discharges with a pH > 9 from the red mud lakes have occurred as the result of storm events. This type of discharge is already regulated under the NPDES program.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

As summarized above, the current red mud management practices and environmental conditions at the five active bauxite facilities may allow some contaminant migration into ground water, surface water, and air, both now and in the future. However, given the generally low concentrations of contaminants in the muds, this migration should not pose a serious human health and environmental threat under reasonable mismanagement scenarios. EPA believes that, after the impoundments have been closed, direct access to the muds should be restricted to avoid radiation hazards and risks. Furthermore, it would be prudent to control fugitive dust emissions from dried or closed impoundments, especially at the facilities located in arid settings, because the dried muds are susceptible to wind erosion and inhalation exposures conceivably could occur if people moved close to inactive impoundments in the future.

EPA believes that the low-risk conclusion for the five active bauxite facilities accurately reflects future conditions because the muds are not likely to be generated and managed at alternate sites. In addition, the quantity of the muds is so large that it is unlikely that the muds will be dredged from the impoundments in which they settle and disposed of elsewhere. Current industry trends also indicate that construction of new bauxite refining facilities in the U.S. is not likely. In addition, the muds historically have not been used off-site extensively. Although a variety of approaches to utilization of the muds have been researched, including use in making construction blocks, bricks, and portland cement, and recovery of iron and other metals, none of these alternatives appear economically viable at present or in the foreseeable future.

The extent of state regulation of red muds appears to be commensurate with the risks posed by this waste. The five active facilities are located in Louisiana, Texas, and Arkansas, of which Louisiana and Texas were studied in detail for purposes of this report. Both Louisiana and Texas exclude mineral processing wastes from hazardous waste regulation and classify red muds generated by alumina production as industrial solid wastes. Although Louisiana's regulations do not contain provisions tailored specifically to red muds, the state does apply surface impoundment and landfill closure and financial responsibility requirements to the muds in a fairly extensive manner. Texas has established standards for all aspects of the control of industrial solid waste. Nevertheless, neither of the two facilities in Texas are required to obtain a permit, because both dispose of their wastes on property owned or controlled by the facility owner/operator, and thus are only subject to notification requirements. Both Louisiana and Texas require State wastewater discharge permits in addition to Federal NPDES permits, and both states address fugitive dust emissions in the air permits issued to the alumina facilities within their jurisdictions.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of red muds, the general absence of documented damages associated with these materials, and the fact that this material does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating red muds from bauxite refining under RCRA Subtitle C.

Chapter 4
Sodium Dichromate Production

The sodium chromate and dichromate (also known as bichromate) production sector consists of two facilities that, as of September 1989, were active and reported generating a special mineral processing waste: treated residue from roasting/leaching of chrome ore. Prior to treatment, the roast/leach residue is not a special waste and thus, is subject to applicable RCRA Subtitle C requirements (see 55 FR 2322, January 23, 1990.)[1] Facilities that are no longer operational, such as the Allied-Signal facility in Baltimore, MD, are not addressed in this report. The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

4.1 Industry Overview

Sodium dichromate, converted from sodium chromate, is the primary feedstock for the production of chromium-containing chemicals and pigments. Chromium-containing chemicals (e.g., chromic acid, basic chromium sulfate, tanning compounds) are used in chromium plating, etching, leather tanning, water treatment, and as catalysts. Other uses of chromium-containing chemicals are in drilling operations to provide drilling mud fluidity and in wood preservative processes to bind copper and arsenic to wood. Chromium pigments represent the largest use of chromium in the chemical industry, with sodium dichromate used to manufacture a multitude of pigments (e.g., chrome green and yellow, zinc chromate) that are used in paints and inks, often for materials that require corrosion inhibition.[2]

The two sodium dichromate production facilities studied in this report are the Corpus Christi, Texas plant operated by American Chrome and Chemicals (ACC) and owned by Harrisons and Crossfield Inc. (Harcross), and the Castle Hayne, North Carolina plant owned and operated by Occidental Chemical Corporation (OCC). The ACC facility initiated operations in 1962 and was modernized in 1985; the OCC facility began operations in 1971 and was modernized in 1982. The annual production capacity, total 1988 production, and rate of capacity utilization for the two facilities as reported in the SWMPF Surveys have all been designated confidential by the facilities and, therefore, are not reported in this document.[3] A published data source lists the annual sodium dichromate production capacity[4] of the ACC plant at 41,000 metric tons and the OCC plant as 109,000 metric tons.[5] According to Bureau of Mines sources, long term capacity utilitzation (1990 to 1995) is forecast to be 100 percent of capacity.[6]

Because these two facilities have classified their production statistics as confidential, no specific information can be given on production trends in the sodium chromate and dichromate industries. The U.S. Bureau of Mines, however, reports that apparent U.S. consumption of chromium has risen from 343,000 metric tons in 1985 to 540,000 metric tons in 1989.[7]

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[1] The residue from roasting/leaching of chrome ore is not "low hazard" (as defined by EPA for purposes of determining the scope of the Mining Waste Exclusion as it applies to mineral processing wastes) when it is removed from the production process and, thus, is not a special waste at the point of generation. However, after treatment (pH adjustment and sulfide reduction), as employed by the two facilities, the residue is "low hazard" and therefore is a special waste because it is also high volume.

[2] Bureau of Mines, 1987. Minerals Yearbook, Ed.; p. 373.

[3] American Chrome and Chemicals and Occidental Chem. Corp. Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[4] Capacities are on a 100 percent sodium dichromate basis and include sodium chromate.

[5] SRI International, 1987. Directory of Chemical Producers--United States, Ed.; p. 964.

[6] Bureau of Mines. 1990. Personal communication with Commodity Specialist John Papp.

[7] John F. Papp, 1987. U.S. Bureau of Mines, "Chromium," Minerals Yearbook, Ed., pp. 221, 223.

Substitutes for chromium chemicals result in increased costs or poor performance.[8] Thus, the future demand for sodium chromate and dichromate will fluctuate directly with the future demand for chromium pigments and the chromium containing chemicals used in chromium plating, etching, tanning, and water treatment, and as catalysts. The chromium chemical industry has historically shown a slow but steady growth rate;[9] there is no indication that this trend will change in the future.

Sodium chromate and dichromate are produced by a process in which ground chrome ore and soda ash are mixed (lime and/or leached calcine are sometimes added as well), roasted in an oxidizing atmosphere, and leached with weak chromate liquor or water, as shown in Exhibit 4-1.[10] The resulting leach liquor is separated from the remaining leach residue. The roasting/leaching sequence is repeated at the ACC facility; that is, two complete chromium extraction cycles are performed prior to removal of the residue. The leach residue is then treated, as discussed below. The treatment residue from this operation is the special waste; it is disposed on-site at both facilities.[11] The leach solution contains unrefined sodium chromate; this liquor is neutralized and then filtered to remove metal precipitates (primarily alumina hydrate).[12] The alumina-free sodium chromate may be marketed, but the predominant practice is to convert the chromate to the dichromate form. The OCC facility uses a continuous process that involves treatment with sulfuric acid, evaporation of sodium dichromate, and precipitation of sodium sulfate. Sodium sulfate may be sold as a byproduct or disposed; the dichromate liquor may be sold as 69 percent sodium dichromate solution or returned to the evaporators, crystallized, and sold as a solid. The ACC plant uses carbon dioxide (CO_2) to convert the chromate to dichromate; this process has the advantage of not generating a sulfate sludge.

Treatment of the leach residue consists of pH adjustment and sulfide reduction. The ACC facility pumps the leach residue directly to a dedicated treatment unit, in which sulfuric acid and sodium sulfide are used to induce the desired chemical changes in the residue, while at the OCC plant, the untreated residue is pumped to a wastewater treatment plant which receives, and apparently combines, several other influent streams prior to treatment with several different chemical agents. At both plants, the treated residue is pumped in slurry form to disposal surface impoundments.

4.2 Waste Characteristics, Generation, and Current Management Practices

The special mineral processing waste generated by sodium dichromate production, treated residue from roasting/leaching of chrome ore, is a solid material, though it typically is generated as a slurry containing particles between 2 mm and about 8 cm (3 inches) in diameter. The treated roast/leach residue is composed primarily of metallic oxides, such as those of iron, aluminum, silicon, magnesium, and chromium, as well as sulfates.[13] The residue treatment process at both facilities includes a step to reduce hexavalent chromium (Cr VI) to the trivalent form (Cr III), and to lower the pH of the waste. During its 1989 sampling visit, EPA observed that the residue (as disposed) has a strong sulfide odor that is indicative of reducing conditions.

Using available data on the composition of the treated residue, EPA evaluated whether the residue exhibited any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on these data and professional judgment, the Agency does not believe the chromium residue is corrosive, reactive, or ignitable. Further, based on EP and SPLP leach test data for one sample from the ACC facility, the chromium residue does not exhibit the characteristic of EP toxicity. Using

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[8] John F. Papp, 1990. U.S. Bureau of Mines, "Chromium," Mineral Commodity Summaries, Ed., p. 45.

[9] John F. Papp, 1985. U.S. Bureau of Mines, "Chromium," Mineral Facts and Problems, Ed., p. 152.

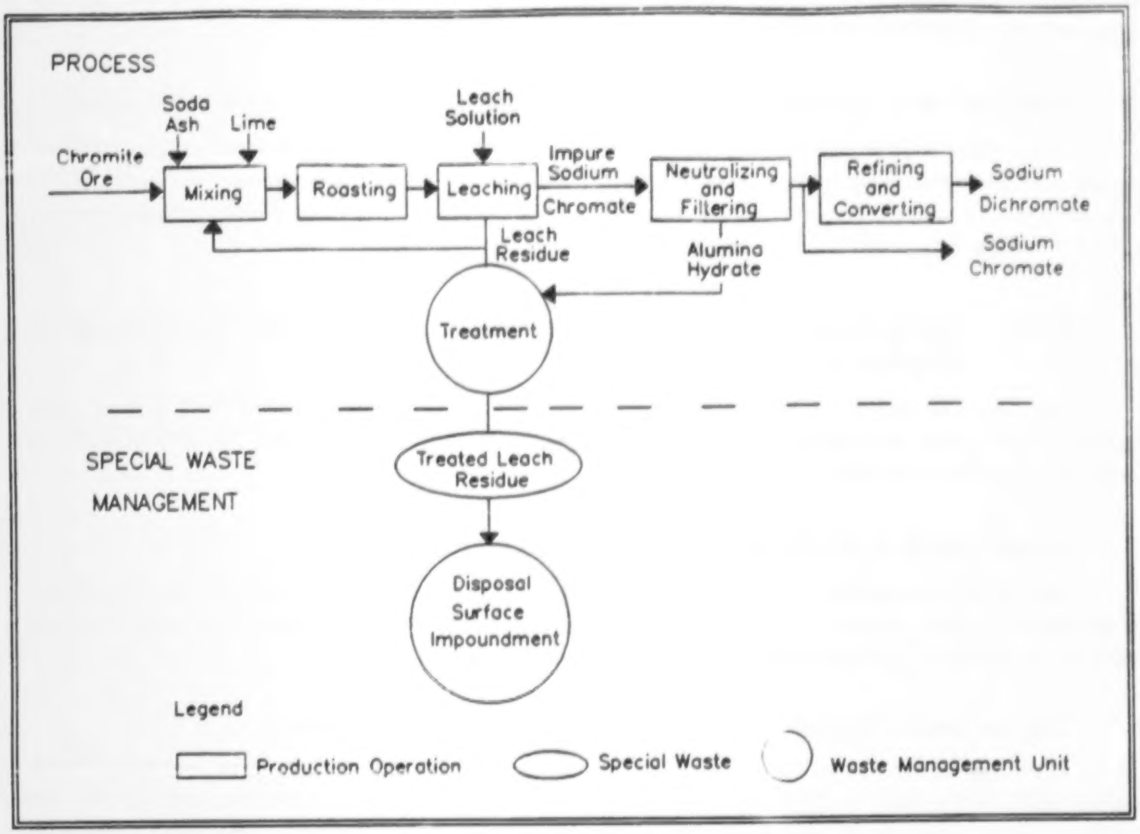
[10] Bureau of Mines, 1985. Mineral Facts and Problems, Ed.; p. 144.

[11] American Chrome and Chemicals and Occidental Chemical Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[12] Marks, 1978. Encyclopedia of Chemical Technology, Marks, et al., editors; Wiley Interscience, New York, NY, pp. 93-94.

[13] Occidental Chemical Corp. Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

Exhibit 4-1
Sodium Dichromate Production


PROCESS
Soda Ash
Lime
Leach Solution
Chromite Ore
Mixing
Roasting
Leaching
Impure Sodium Chromate
Neutralizing and Filtering
Refining and Converting
Sodium Dichromate
Sodium Chromate
Leach Residue
Alumina Hydrate
Treatment
SPECIAL WASTE MANAGEMENT
Treated Leach Residue
Disposal Surface Impoundment
Legend
Production Operation
Special Waste
Waste Management Unit

the EP test, the concentrations of all eight inorganic constituents with the EP toxicity regulatory levels were one to two orders of magnitude below the regulatory levels.

Both companies generating this waste indicated that waste generation rate data were confidential business information. Using alternate sources, EPA estimates the total generation to be approximately 102,000 metric tons/year (mt/yr); the estimated waste to product ratio is 0.68 metric ton of treated residue to each metric ton of sodium dichromate.

The waste management practice used at both sodium dichromate production facilities is the disposal of the treated roast/leach residue in large surface impoundments.[14] In these impoundments, the treated roast/leach residue is settled out; the water is removed, treated, and discharged at the OCC facility, and is typically left in the impoundment (evaporates) at the ACC facility. The settled treated roast/leach residue is not removed from the impoundments but accumulates in place. The volume of treated roast/leach residue accumulated on-site at the two sodium dichromate plants is estimated to total more than 1 million metric tons; the facilities have reported accumulations of 54,000 cubic meters (1.9 million cubic feet) and 440,000 cubic meters at ACC and OCC, respectively. Other waste streams are co-managed with the treated roast/leach residue at these facilities.

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[14] The OCC impoundment at Castle Hayne is actually a quarry. The treated roast/leach residue is co-managed in this quarry with tailings from another on-site operation (identity is confidential). The ACC impoundment is termed a residue disposal area.

The average surface area of these impoundments is 254,000 square meters (62.8 acres) with a depth of 7.3 meters (24 feet); the specific impoundments range in surface area from 22,000 square meters and a depth of 2.5 meters for ACC/Corpus Christi's residue disposal area to a surface area of 486,000 square meters and a depth of 12 meters at OCC/Castle Hayne's quarry. Neither facility uses a liner or a leachate collection system, and only Occidental has surface and ground-water monitoring.

4.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proven. Overall conclusions about the hazards associated with treated chromium roast/leach residue are provided after these two study factors are discussed.

4.3.1 Risks Associated with Treated Residue from Roasting/Leaching of Chrome Ore

Any potential danger to human health and the environment from the treated residue from roasting/leaching of chrome ore depends on the presence of toxic constituents in the waste that may pose a risk and the potential for exposure to these constituents.

Constituents of Potential Concern

EPA identified chemical constituents in the treated residue from roasting/leaching of chrome ore that may potentially present a hazard by collecting data on the composition of the waste and evaluating the intrinsic hazard of the residue's chemical constituents.

Data on Treated Residue from Roasting/Leaching of Ore Composition

EPA's characterization of the treated roast/leach residue and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW). These data provide information on the concentrations of 20 metals in samples of both the treated residue and leachate (e.g., EP-toxicity procedure, SPLP). Wastes from both sodium dichromate production plants within the scope of this study were sampled and analyzed.

Data on constituent concentrations in solid samples of the waste from the OCC plant are not available; therefore, concentrations in solid samples cannot be compared for the two facilities. On the other hand, concentrations from leachate analyses of the treated roast/leach residue were available for both facilities and generally are consistent across the two facilities and two types of leach tests (i.e., EP and SPLP).

Process for Identifying Constituents of Potential Concern

As discussed in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if treated chromium roast/leach residue contains any chemical constituents that may pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to the screening criteria and then by evaluating the environmental persistence and mobility of the constituents present in concentrations that exceed the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which constituents in the residue are released to the environment and migrate to possible exposure points. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic organisms, and air and water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Analysis of solid samples of the treated roast/leach residue indicates that none of the waste's constituents are present at levels above the screening criteria. That is, even under conservative release and exposure conditions, the residue solids do not appear to contain any constituents in concentrations that could pose a significant risk.

Exhibit 4-2 presents the results of the comparisons for treated residue leachate analyses, and lists all constituents for which sample concentrations exceed a screening criterion. Chromium, vanadium, aluminum, manganese, and arsenic are present at concentrations equal to or slightly greater than at least one of their respective screening criteria. All of these constituents are inorganics that do not degrade in the environment.

None of the constituents are present at a concentration more than five times a screening criterion, and arsenic is present at a concentration that is just equal to its human health screening criterion. Vanadium and arsenic leachate concentrations are high enough that, if the leachate migrated to drinking water sources with only a 10-fold dilution, long-term ingestion of untreated drinking water could cause adverse health effects. If the leachate is released and diluted by only a factor of 10, chromium, vanadium, and manganese concentrations could potentially render affected ground or surface waters unsuitable for a variety of uses (e.g., direct human consumption, irrigation, livestock watering). Chromium and aluminum are present in the treated residue leachate at concentrations that, if released to surface waters with a 100-fold dilution or less, could exceed criteria for the protection of aquatic life. It is important to clarify that, while the concentrations of these five constituents exceed the conservative screening criteria, no constituents were measured in concentrations that exceed an EP-toxicity regulatory level.

These exceedances of the screening criteria, by themselves, do not demonstrate that the residue poses a significant risk, but rather indicate that the waste may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the residue to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the waste.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of the waste as it was generated and managed at the two sodium dichromate production plants in 1988. It does not assess the hazards of off-site use or disposal of the treated residues because the treated residues are currently managed only on-site and are not likely to be managed off-site in the foreseeable future. In addition, the following analysis does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on which to base projections of future conditions. Alternative practices for the management of treated chrome roast/leach residue, however, are discussed in Section 4.5.

Ground-Water Release, Transport, and Exposure Potential

As discussed above, leachate from the treated chromium residue contains five constituents in concentrations that exceed the risk screening criteria. However, given the existing residue management practices and the neutral pH conditions that are expected to exist in and under the waste management units, vanadium, aluminum, and manganese have a strong tendency to bind to soil. These three constituents in leachate from the treated residue, therefore, are relatively immobile in ground water (in the event that they are released to ground water). Moreover, the residue treatment process employed is designed to reduce

Exhibit 4-2
Potential Constituents of Concern in Treated Chromium Roast/Leach Ore Residue Leachate[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Chromium	2 / 2	Resource Damage Aquatic Ecological	2 / 2 1 / 2	2 / 2 1 / 2
Vanadium[(c)]	2 / 2	Human Health Resource Damage	1 / 2 1 / 2	1 / 2 1 / 2
Aluminum[(c)]	2 / 2	Aquatic Ecological	2 / 2	2 / 2
Manganese	1 / 2	Resource Damage	1 / 2	1 / 2
Arsenic[(c)]	1 / 2	Human Health*	1 / 2	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3 in Chapter 2 of this report. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP leach test results.

chromium to the trivalent form, which is relatively immobile in typical ground-water systems.[15] Therefore, among the constituents of potential concern in leachate from the treated residue, only arsenic would be expected to be readily transported in typical ground-water environments, if released.

Both sodium dichromate production facilities manage the treated residue in units that have no engineered ground-water release controls such as liners or leachate collection systems. However, the ground-water release and transport potential of these units differ significantly:

- The OCC plant in North Carolina discharges the residue slurry into a 49 hectare (120 acre) quarry that is 12 meters deep. The depth of supernatant liquid in this impoundment provides a large hydraulic head that may produce a considerable force to drive liquids from the quarry into the underlying aquifer. Because the quarry is located in karst terrain (i.e., irregular topography characterized by solution features in soluble rock), any liquids released from the quarry to the aquifer located six meters beneath the quarry could potentially flow long distances directly through conduits in the bedrock (i.e., with minimal contaminant dilution and attenuation) to potential exposure points.
- The ACC facility in Texas discharges the residue slurry to an unlined disposal area that has little or no standing water except during storm events and immediately following deposition of fresh residue slurry. Water is removed from the unit via a network of drainage ditches, by evaporation, and by seepage into the ground. Although there is little hydraulic head to drive the flow of contaminants from the unit, both slurry water

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[15] For all other mineral processing wastes evaluated in this report, chromium is assumed to be present in its hexavalent form and, therefore, to be relatively mobile in ground water.

> and stormwater potentially can leach contaminants from the residue into the subsurface. The potential for slurry water and stormwater to infiltrate to ground water from this unit may be limited to some degree by the presence of relatively impermeable subsurface materials (i.e., composed primarily of clay) in the vicinity of the site.

Given these management unit and hydrogeological characteristics, the potential for seepage from the disposal units to migrate into ground water is relatively high at the North Carolina facility and moderate at the Texas facility. Ground-water monitoring data further support this assessment. Monitoring of ground water at the North Carolina facility has indicated that drinking water standards for chloride and pH have been exceeded downgradient (but not upgradient) of the waste management area. While these contaminants are not associated with the treated chromium residue, the presence of contaminants in the ground water indicates the potential for contaminants to leach into ground water at this site.[16] Ground-water contamination has also been documented at the Texas facility (see Section 4.3.2). Although the ground-water contamination at the Texas facility has not been attributed to the treated residue management unit, the presence of contamination again indicates that hydrogeologic conditions at this location do not preclude the potential release of residue constituents to ground water.

Ground-water flow in karst terrain, such as that at the OCC plant, is typically characterized as conduit flow that does not provide the intimate contact between aquifer material and ground water that occurs in typical porous media aquifers. Consequently, the constituents of potential concern (i.e., trivalent chromium, vanadium, aluminum, and manganese) that would not be mobile in typical ground-water environments can migrate more readily in karst limestone aquifers, and may be mobile along with arsenic at the OCC plant.

Currently, there are no residential or public water supply withdrawals from ground water within 1.6 km (1 mile) downgradient of either facility. Therefore, current human health risks resulting from drinking water exposures are not expected. Potential releases of arsenic, chromium, vanadium, and manganese from the waste to the aquifer at the OCC plant, and potential releases of arsenic at the ACC plant could restrict potential future uses of the ground water, but this threat is very minor given the low concentration of the waste leachate. In theory, contaminants migrating into ground water at the OCC facility could remain at levels above the screening criteria for relatively long distances because conduit flow does not disperse contaminants as readily as diffuse flow in porous media. However, in reality, any contaminants released to ground water at the OCC facility are likely to discharge directly into the adjacent northeast Cape Fear River, as described in the next section.

Surface Water Release, Transport, and Exposure Potential

Constituents of potential concern in treated roast/leach residue could theoretically enter surface waters by either migration of leachate through ground water that discharges to surface water, or direct overland (stormwater) run-off of dissolved or suspended materials. As discussed above, arsenic, chromium, aluminum, manganese, and vanadium leach from treated chrome residue at levels above the screening criteria. Given the characteristics of the units currently used to manage this waste at the two sodium dichromate production facilities and the hydrologic setting of the plants, the potential for releases of treated residue constituents to surface waters varies between the two plants.

The OCC plant in North Carolina is located adjacent to the Northeast Cape Fear River. Because the waste is managed as a sludge at the bottom of a quarry that is 12 meters deep, however, it is unlikely that overland flow of stormwater run-off could carry the waste to the river. Ground-water discharge to surface water could potentially release contaminants from the residue sludge to the river at concentrations above the screening criteria. However, resulting contaminant concentrations in the river downstream of the facility are expected to be negligible because the large flow of the river (1,250 mgd) can provide substantial dilution, and the constituents that exceed the screening criteria exceed it by a factor of less than five.

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[16] The facility did not provide information on the possible sources of the observed ground-water contamination.

The ACC plant in Texas is located less than 50 meters from the Corpus Christi shipping channel. Releases from the treated residue disposal area are expected to be moderated by run-on/run-off controls designed to restrict surface run-off of stormwater and slurry water from the unit. As discussed above, the potential for contamination of ground water is moderate at this facility, and, consequently, contaminated ground water potentially could discharge to the shipping channel. However, because the Agency's comparison of treated chrome residue concentrations to screening criteria does not indicate any potential impacts on saltwater ecosystems or restrictions on potential beneficial uses of saltwater, threats to the shipping channel water quality from treated chromium residue appear unlikely.

Air Release, Transport, and Exposure Potential

EPA's comparison of constituent concentrations to screening criteria did not identify any potential constituents of concern for the air pathway. Consequently, if airborne releases were to occur, possibly due to future removal of the residue sludge from the current management areas, chrome residue should pose no human health threats via the air pathway. Air pathway threats from current management of the residue at the OCC plant are further diminished because the waste is managed as a sludge at the bottom of a quarry, submerged beneath a liquid.

Proximity to Sensitive Environments

Both the OCC and ACC plants are located in environments that are vulnerable to contamination or have high resource value. Because the OCC plant is located in a 100-year floodplain, large releases occasionally could occur in the event of a large flood. The OCC plant also is located in an area of karst topography, which may permit the ready transport of contaminants if they are released to ground water. Both sodium dichromate production facilities are within 1.6 km (1 mile) of a wetland area. However, because the ground-water and surface water release potential at the ACC facility is considerably smaller, only the wetland area near the OCC plant may be potentially threatened by releases from the residue. Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural waters, provide flood and storm damage protection, and afford a number of other benefits.

Risk Modeling

The intrinsic hazard of the treated residue is generally low because the residue does not exhibit any of the four characteristics of a hazardous waste and contains only five constituents that exceed the screening criteria by a narrow margin (less than a factor of five). Migration into ground and surface water is possible at both sites, but it is not expected to cause significant human health or environmental impacts for the reasons outlined above. In addition, there are no documented cases of damage attributable to the treated residue (as presented in the next section) and the Agency's modeling of other wastes that appear to pose a greater hazard suggest that the risks posed by the treated residue are low. For all of these reasons, EPA has concluded that the potential for treated residue from roasting/leaching of chrome ore to pose significant risk to human health or the environment is moderate to low. (See sections 4.3.3 and 4.7 for additional discussion.) Therefore, the Agency has not conducted a quantitative risk modeling exercise for this waste.

4.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the performance of waste management practices for treated residue from the roasting/leaching of chrome ore. The file reviews were combined with interviews with Texas and North Carolina State and EPA regional regulatory staff. Through these case studies, EPA found no documented environmental damages attributable to management of the treated residue from chrome ore processing. Ground-water contamination has been identified at the American Chrome and Chemical facility, but it is not clear to what extent current waste disposal practices, historical waste disposal practices (which involved management of an untreated residue), and/or neighboring facilities are the source of the contamination.

Contacts with State agencies and review of State files also revealed that historical management practices of the untreated chrome ore processing residues have created numerous sites where remediation (by removal or other means) is planned or in progress.[17] Examples include: (1) the Allied Chemical plant in Baltimore, MD; (2) the city of Baltimore's Patapsco Wastewater Treatment Plant and other sites on Baltimore Harbor where untreated chrome ore residues from the Allied Chemical facility were used as fill material; and (3) more than 100 sites in Hudson County, New Jersey (includes Jersey City, Kearny, and Secaucus), where use of the untreated residues (from three facilities -- Allied Chemical Corp., PPG Industries, and Diamond Shamrock Co.) in an urban setting resulted in chromium contamination of surficial soil, with associated contamination of ground and surface water, sediment, building walls, and ambient air.

4.3.3 Findings Concerning the Hazards of Treated Residue from Roasting/Leaching of Chrome Ore

Review of the available data on treated residue indicates that none of the waste's constituents are present at levels above the screening criteria in samples of the treated residue solids. The available data also indicate that the treated residue does not exhibit any of the four characteristics of hazardous waste. Data on constituent concentrations in laboratory leachate from the treated residue indicate that concentrations of chromium, vanadium, aluminum, manganese, and arsenic occur above screening criteria. None of the constituents, however, are present at a concentration more than five times a screening criterion, and arsenic is present at a concentration that is just equal to its human health screening criterion. Given the very conservative nature of these screening criteria, these low contaminant concentrations in leachate from the treated residue would pose a significant risk only under extreme exposure conditions.

The potential for release, transport and exposure is notably different at the two currently active facilities. The ground-water release potential is high at the North Carolina facility and moderate at the Texas facility, but the potential for risks resulting from drinking water exposure is low at both facilities because of the low concentration of the leachate and because any contaminated ground water is likely to discharge directly into adjacent surface waters without being withdrawn for drinking. At the North Carolina facility, it is unlikely that release to surface waters via overland flow would occur, but migration through ground water that discharges to surface water could occur. No significant impacts would be expected, however, due to the large flow of the river. At the Texas plant, erosion to surface waters should be mitigated by run-off controls, but releases through ground-water discharge to the Corpus Christi Shipping Channel could potentially occur. The shipping channel contains saltwater, and comparison of leachate concentrations to the screening criteria did not indicate any potential impacts to saltwater ecosystems. No constituents of potential concern were identified for releases to air.

Based on the relatively low intrinsic hazard of the waste, the low potential for release, transport, and exposure, and the absence of documented cases of danger to human health or the environment, EPA has tentatively concluded that the hazard posed by treated residue from the roasting/leaching of chrome ore is relatively low. Accordingly, only limited discussions of current applicable regulatory requirements, alternative waste management and utilization, and costs and impacts are provided below.

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[17] EPA has previously determined that untreated chromium roast/leach ore residue is not a low hazard waste and, therefore, it is not within the scope of this Report to Congress. (See 54 FR 36592, September 1, 1989.)

4.4 Existing Federal and State Waste Management Controls

4.4.1 Federal Regulation

Although there are a number of Federal statutes and regulations which apply to various industrial wastes generally (including those from ore mining and dressing and certain types of primary metal production), there are none that specifically address solid wastes from chrome ore processing. It should be noted, however, that untreated roast/leach residue and any additional wastes generated by chrome processing operations that may exhibit a characteristic of hazardous waste are subject to Subtitle C of RCRA, as of the effective date (July 23, 1990) of the final rule establishing the boundaries of the Mining Waste Exclusion (55 FR 2322, January 23, 1990).

4.4.2 State Regulation

The nation's two chromium facilities are located in two states, North Carolina and Texas, both of which were selected for regulatory review for the purposes of this report (see Chapter 2 for a discussion of the methodology used to select states for detailed regulatory study). Both North Carolina and Texas have adopted the federal exclusion from hazardous waste regulation for mineral processing wastes.

North Carolina does not regulate roasting/leaching residue from chrome ore under its solid waste regulations, but does address this waste under state water pollution control regulations. North Carolina has an approved NPDES program and requires that its single chromium facility maintain a "no discharge" permit for the impoundments used for settling and disposing of the treated residue. Under the terms of this permit, the facility must undertake activities such as weekly EP-toxicity testing, ground-water monitoring, and personnel certification. The permit also stipulates that a closure plan must be submitted for approval three months prior to closure of the impoundment. Finally, the facility's impoundment used for the disposal of treated roasting/leaching ore residue is not subject to specific requirements in the facility's air permit, though a recently promulgated toxic air pollutants regulation may result in the application of more stringent requirements.

Texas classifies roast/leach residue from chrome ore as industrial solid waste. Because the chromium facility in Texas disposes of its roast/leach ore residue on land that is both within 50 miles of the facility and controlled by the facility owner/operator, the state has not required that the facility obtain a solid waste disposal permit. The facility is required to notify the state of its waste management activities, however, and may be required to submit additional information such as waste characterization data. Moreover, all discharges to surface water in the state must be permitted under both federal NPDES and state water quality discharge permits. Finally, although the single chromium facility in Texas maintains an air permit, the permit does not specifically address the roasting/leaching residue surface impoundments managed at the facility.

In summary, both of the states with chromium facilities, North Carolina and Texas, regulate the chrome ore roasting/leaching residues generated at those facilities under solid waste and/or water quality regulations. Of the two states, North Carolina appears to be somewhat more comprehensive in the kinds of environmental controls required and the stringency of those controls. Finally, neither of the facilities' state-issued air permits specifically address, at this time, the roasting/leaching residue management and disposal units used by the facilities, though North Carolina may impose more stringent requirements under newly promulgated toxic air pollutants regulation.

4.5 Waste Management Alternatives and Potential Utilization

As noted above, while the treated residue from roasting/leaching of chrome ore could pose a risk under a very conservative set of conditions, the risk analysis indicates that significant impacts are unlikely. Consequently, the issue of how sodium dichromate producers might modify their operations or waste management practices or be stimulated to develop alternative uses for the treated roast/leach residue in response to prospective hazardous waste regulation is not applicable. Nevertheless, EPA did search the literature for information on research into alternatives for disposal and potential utilization of the treated residue, but no relevant information was identified.

4.6 Cost and Economic Impacts

Because the available data indicate that treated residue from roasting/leaching of chrome ore does not exhibit any of the characteristics of hazardous waste and is unlikely to pose significant risks to human health and the environment, the issue of how waste management costs might change because of new requirements associated with regulation under RCRA Subtitle C and what impacts such costs might impose upon affected facilities has not been investigated.

4.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of the treated residue from roasting/leaching of chrome ore is relatively low compared to other mineral processing wastes studied in this report. The treated residue does not exhibit any of the four characteristics of hazardous waste. Data on constituent concentrations in solid samples of the waste also do not indicate any exceedance of the screening criteria used in this analysis. Data on constituent concentrations in laboratory leachate from the treated residue, however, indicate that five constituents are present in concentrations above the conservative screening criteria. However, none of these constituents are present at a concentration more than five times the screening criterion, and given the conservative nature of these screening criteria, these low contaminant concentrations in leachate from the treated residue would pose a significant risk only under extreme exposure conditions.

In addition to the relatively low intrinsic hazard of this waste, current management of the waste at the facilities in North Carolina and Texas appears to limit the potential for the waste to threaten human health or the environment. Although the ground-water release potential is relatively high at the North Carolina facility and moderate at the Texas facility, the potential for exposure resulting from drinking water is low at both facilities because of the low concentrations of the waste leachate and because any contaminated ground water is likely to discharge directly into adjacent surface waters without being withdrawn for drinking (i.e., the waste management units are located very near surface waters and it is unlikely ground water would be withdrawn between the management units and the point of discharge into the surface water). At the North Carolina facility, releases to surface waters via overland flow are unlikely, and releases through ground-water discharge would not be expected to produce significant impacts because of the large flow of the river adjacent to the plant. At the Texas plant, overland releases to surface waters would be mitigated by run-off controls, and no adverse impacts are expected in the event of ground-water discharges to the adjacent saltwater system because constituent concentrations in leachate from the treated residue are below concentrations that threaten saltwater organisms.

The lack of documented cases of damage caused by the treated residue confirms that the waste, as currently managed, appears not to cause significant health or environmental impacts. Review of State and EPA Regional files and interviews of State and EPA Regional regulatory staff did not produce any evidence of documented environmental damages attributable to management of treated residue at the Texas or North Carolina facilities.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The relatively low intrinsic hazard of the waste and the current waste management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment are expected to continue to limit risks in the future in the absence of Subtitle C regulation. The characteristics of this waste are unlikely to change in the future, and despite the fact that this analysis is limited to the two sites at which the waste is currently managed, EPA believes that the conclusion of low hazard can be extrapolated into the future because the environmental conditions in which the waste is managed are unlikely to change. Management of treated residue is unlikely to expand beyond the two locations currently in use for three reasons. First, the quantity of material involved makes it unlikely that the treated residue from roasting/leaching of chrome ore would be removed from the impoundments for disposal elsewhere. Second, current trends in industry growth indicate that construction of additional sodium dichromate production facilities is not likely. Third, the treated roast/leach residues have historically not been used off-site, and no viable approaches to utilization of the treated residue have been identified.

At the facility in North Carolina, the potential for increased risks in the future is further restricted by substantial State regulation of the treated residue disposal unit. The requirements for this unit, which are incorporated in a state-administered water quality permit, include no discharge from the impoundments used for settling and disposal of the treated residue, weekly EP-toxicity testing, ground-water monitoring, a compliance boundary where water quality standards must be met, and operation of the unit by a certified operator. At the Texas facility, in contrast, the State's application of environmental control requirements for waste management activities is limited.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of treated residue from roasting/leaching of chrome ore, the general absence of documented damages associated with this material, and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating treated residue from roasting/leaching of chrome ore under RCRA Subtitle C.

Chapter 5
Coal Gasification

The domestic coal gasification industry presently consists of one facility that, as of September 1989, was the only commercial coal gasification plant in full operation in the United States[1] that reported generating two special mineral processing wastes: gasifier ash and process wastewater. The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

5.1 Industry Overview

The coal gasification facility produces synthetic natural gas that is sent to a refinery for processing as a natural gas for energy production. The Great Plains Coal Gasification Plant is located in Beulah, Mercer County, North Dakota and is owned and operated by the Dakota Gasification Company. The Great Plains facility began operation in 1984. The facility reported an annual capacity of 1.1 million metric tons in 1988, and an actual production of 1.0 million metric tons of natural gas.

The Great Plains plant set a new annual production record for 1989 with a 9.8 percent increase over its 1988 level and a 5.1 percent increase over 1987 production.[2] The profitability of existing facilities and the potential for the opening of new plants will be affected by the prices of alternative fuel sources such as oil and gas.

The facility employs 12 Lurgi Mark IV high pressure coal gasifiers, with two gasifiers on standby for spare capacity. The overall coal gasification process is illustrated in Exhibit 5-1. Lignite coal, which is taken from four mines that are co-located with the facility, is crushed and fed to the top of individual gasifiers through a lock-hopper system; steam and compressed oxygen are introduced at the bottom of each gasifier. As the coal charge descends through the gasifier bed, it is dried, devolatilized, and gasified. The ash remaining in the bed after the reaction is removed by a rotating grate at the bottom of the gasifier and is discharged through a gas lock. The ash is discharged into an enclosed ash sluiceway, where recirculating ash sluice water is introduced to cool the ash and transport it to the ash handling and disposal area. The hot crude product gas leaving the gasifiers goes through several operations, including quenching (to cool and clean), shift conversion (to alter the ratio of hydrogen to carbon monoxide), further cooling of the gas, and processing through the Rectisol unit (to remove sulfur compounds and carbon dioxide). The desulfurized crude gas is sent to the methanation unit; the product gas is then compressed and dried for delivery to a pipeline for distribution.[3]

The quenching operation described above, in addition to cooling the raw gas, serves to remove entrained particles from the gas and to condense and remove unreacted steam, organic compounds, and soluble gases. The result of this cooling operation is an aqueous stream known as quench liquor. This process stream, along with similar streams from the shift conversion, gas cooling, and rectisol units, are sent to the gas liquor separation unit (for removal of tar and oil), to a phenosolvan unit (for phenol recovery), and to a phosam-W

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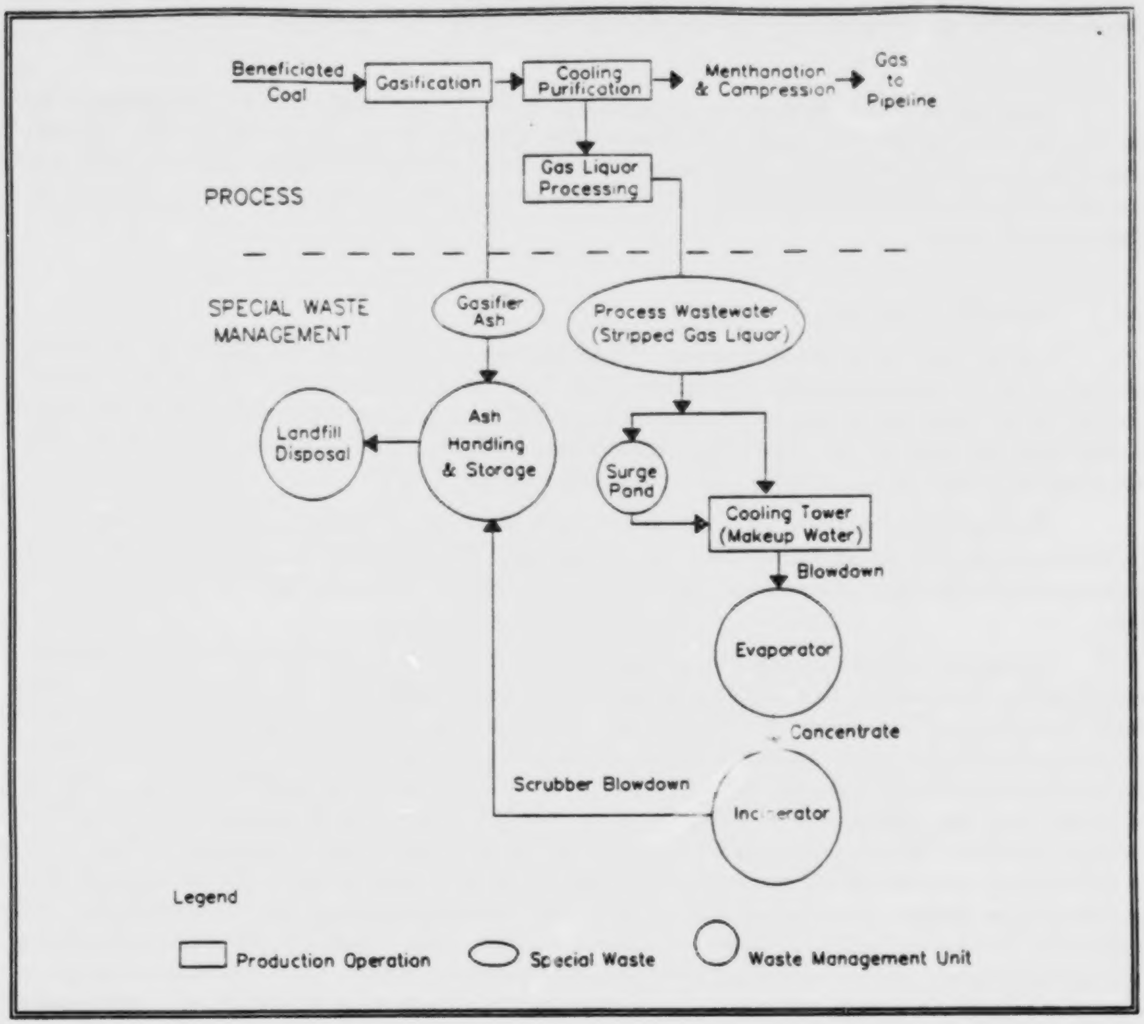
[1] EPA is aware of two other facilities that conduct commercial-scale coal gasification operations. These plants, located at Daggett, California and Placamine, Louisiana, employ a different technology than that used at the Beulah, North Dakota facility that is the subject of this chapter. The facility in California has been inactive since early 1988 and is currently being overhauled so that it can burn a mixture of 75 percent coal and 25 percent sewage sludge. The Louisiana facility is currently operating and gasifies about 2,400 tons per day of coal. EPA is continuing to collect information on waste generation, management practices, and process operations at these facilities to determine if the regulatory determination will apply to any wastes generated by these facilities.

[2] "The Bulletin," 1990. Great Plains Synfuels-Dakota Gasification Company, Volume 7, No. 3, January 16, p. 4.

[3] Environmental Protection Agency, 1987. American Natural Gas Special Study. Prepared by CDM for the U.S. EPA, Washington, D.C., March, 1987; pp. 14-27.

Exhibit 5-1
Coal Gasification


Beneficiated Coal
Gasification
Cooling Purification
Menthanation & Compression
Gas to Pipeline
Gas Liquor Processing
PROCESS
SPECIAL WASTE MANAGEMENT
Gasifier Ash
Process Wastewater (Stripped Gas Liquor)
Landfill Disposal
Ash Handling & Storage
Surge Pond
Cooling Tower (Makeup Water)
Blowdown
Evaporator
Concentrate
Scrubber Blowdown
Incinerator
Legend
Production Operation
Special Waste
Waste Management Unit

ammonia recovery unit (for ammonia recovery). The process water leaving the phosam-W unit, known as stripped gas liquor, is the special waste, coal gasification process wastewater. This process wastewater is used as make-up water for a water cooling system that is needed to cool the gasifiers during operation. The hot water is routed to a cooling tower used to remove heat from the system. The evaporation from the cooling tower exceeds the quantity of stripped gas liquor generated on an annual basis; hence, all stripped gas liquor is used as make-up water.

5.2 Waste Characteristics, Generation, and Current Management Practices

The coal gasification operation discussed in this report generates both a solid special mineral processing waste, gasifier ash, and an aqueous process waste, stripped gas liquor.

Gasifier Ash

Gasifier ash, which reportedly has a particle size ranging from two millimeters to eight centimeters in diameter (gravel), is composed primarily of sulfate, calcium, silicon, sodium, aluminum, and magnesium. The Dakota gasification facility reported generating 245,000 metric tons of gasifier ash in 1989.

Using available data on the composition of coal gasification gasifier ash, EPA evaluated whether the ash exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on professional judgment and analyses of 59 gasifier ash samples from the Beulah facility, the Agency does not believe the ash is corrosive, reactive, ignitable, or EP toxic.

Gasifier ash that is removed from the bottom of the gasifier is quenched, passed through crushers to reduce the maximum size to eight centimeters, then sluiced into ash sumps for settling and dewatering. The dewatered ash is trucked to an on-site clay-lined landfill, where it is disposed along with ash from boilers, superheaters, and incinerators, and settled solids from process water management units (e.g., impoundments, API separators).

The landfill is 23 meters (75 feet) deep with an area of 4.9 hectares (12 acres) and is lined with recompacted clay. Although the landfill receives a variety of wastes, the ash accounts for approximately 95 percent of the total input. Material is typically not removed from the landfill and the remaining life is five years. A total of 1,500,000 metric tons[4] of combined solids has accumulated at the solid waste disposal site, approximately 95 percent of which is assumed to be gasifier ash based on Survey responses.

Process Wastewater

The process wastewater has an average pH of 9.8 and a solids content of approximately 0.2 percent. The principal contaminant in the water reportedly is NO_3, with additional trace amounts of chlorides, sodium, phenols, and oil and grease. The Dakota gasification facility reported generating 4.83 million metric tons of process wastewater during 1988.

Using available data on the composition of coal gasification process wastewater, EPA evaluated whether the wastewater exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on professional judgment and analyses of two process wastewater samples from the Beulah facility, the Agency does not believe the wastewater exhibits any of these characteristics. Using the EP leach test, for example, all of the inorganic constituents with EP toxicity regulatory levels, except selenium, were measured in concentrations that were at least two orders of magnitude below the regulatory level; the maximum observed concentration of selenium in EP leachate was 0.4 times the regulatory level.

The process wastewater (i.e., stripped gas liquor) is used as make-up water for the gasifier water-cooling system. In this system, large quantities of water are lost to evaporation (3,000-3,500 gpm, or 6-7 million metric tons per year) from the cooling tower. Evaporation losses are made up using primarily the stripped gas liquor, as well as softened ground water and other on-site wastewaters. Although the quantity of water lost from the gasifier cooling system through evaporation exceeds the quantity of process wastewater generated on an annual basis, the supply of process wastewater generated on a daily basis sometimes exceeds the need for cooling system make-up water. When this occurs, a surge pond is used to store the process wastewater until it is needed. This impoundment, which is lined with recompacted local clay and a 36 mil synthetic liner, has an area of about 4.3 hectares (11 acres) and a depth of 4 meters (13 feet). No long-term accumulation of waste occurs in this unit; the water is pumped to the cooling tower and settled solids are dredged (approximately 13 metric tons in 1988) and sent to the solid waste disposal landfill.

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[4] Quantity was originally reported in cubic yards (960,000 cubic yards). This was converted to metric tons assuming a specific gravity of 2.0 for the ash sludge.

The evaporation of water from the cooling water system results in any impurities in the make-up water being concentrated in the remaining cooling system water; these impurities can lead to scaling or other operational problems in the system. Therefore, the cooling water in the system is bled off at a rate of 360-500 gpm to prevent concentration of impurities from reaching unacceptable levels. This concentrated bleed, known as cooling tower blowdown, was generated at a rate of approximately 766,000 metric tons in 1988.

This cooling tower blowdown and the residuals from the treatment of the waste stream are not special wastes (because they are not large volume wastes), but the management of these streams is discussed briefly to provide an overview of the operation. The cooling tower blowdown is treated in a multiple effects evaporator (MEE) unit. Distillate from this treatment is returned to the cooling system or used as other facility utility water. The remaining residual, MEE concentrate, is returned as feed to the gasifier or is sent to an on-site liquid waste incinerator (LWI). Separate surge ponds are used for storage of MEE distillate and concentrate. The waste stream from the LWI unit, referred to as LWI blowdown, is sent to the coal ash sluice area to be included as make-up water for ash handling. Any incinerator ash/solids in the blowdown are, therefore, combined with the gasifier ash and managed as such.[5]

5.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proven. Overall conclusions about the hazards associated with coal gasifier ash and process wastewater are provided after these two study factors are discussed.

5.3.1 Risks Associated with Gasifier Ash and Process Wastewater

Any potential danger to human health and the environment from coal gasifier ash and process wastewater depends on the presence of toxic constituents in the wastes that may pose a risk and the potential for exposure to these constituents.

Constituents of Potential Concern for Coal Gasification Gasifier Ash

EPA identified chemical and radiological constituents in coal gasifier ash that may present a hazard by collecting data on the composition of the waste and evaluating the intrinsic hazard of the ash's constituents.

Data on Coal Gasifier Ash Composition

EPA's characterization of the gasifier ash and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW) and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, radium-226, uranium-238, gross alpha and beta radiation, cyanide, a number of other inorganic constituents (i.e., phosphate, fluoride, and sulfate), and 30 semivolatile and volatile organic constituents in total and leach test analyses.

Concentrations in total samples of the ash are consistent for most constituents across the two data sources. Likewise, concentrations from leach test analyses of the gasifier ash generally are consistent across the two data sources. Among EP results, however, arsenic, barium, chromium, and silver concentrations vary by more than two orders of magnitude. In addition, maximum leachate concentrations of many constituents (i.e., arsenic, barium, cadmium, chromium, copper, lead, manganese, selenium, and silver) detected in EP leach tests are approximately 10 times higher than concentrations detected by SPLP or TCLP analyses. Conversely, concentrations of aluminum, iron, uranium-238, and vanadium detected by SPLP analyses are greater than approximately five times the highest EP and TCLP concentrations.

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[5] As reported by Dakota Gasification Company, approximately 32,000 metric tons of LWI blowdown was generated in 1988 with a solids content of 5 percent; these approximately 1,600 metric tons of solids are assumed to be included in the total volume of gasifier ash reported by the company.

Process for Identifying Constituents of Potential Concern

As discussed in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if coal gasifier ash contains any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to the screening criteria, and then by evaluating the environmental persistence and mobility of constituents that are present in concentrations that exceed the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which constituents in the wastes are released to the environment and migrate to possible exposure points. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic organisms, and air and water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibits 5-2 and 5-3 present the results of the comparisons for gasifier ash total analyses and leach test analyses, respectively, to the screening criteria. These exhibits list all constituents for which sample concentrations exceed a relevant screening criterion.

Of the 58 constituents analyzed in the ash solids, only uranium-238, thallium, arsenic, and chromium concentrations exceed the screening criteria. Among these constituents, uranium-238, thallium, and arsenic exceed the screening criteria with greater frequency and magnitude. However, only arsenic is present at a concentration that exceeds a screening criterion by a factor of more than 10. These exceedances of the screening criteria indicate the potential for a variety of impacts, as follows:

Exhibit 5-2
Potential Constituents of Concern in Coal Gas Ash Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/No. of Analyses for Constituent
Uranium-238	1 / 1	Inhalation* Radiation*(c)	1 / 1 1 / 1
Thallium	3 / 3	Ingestion	2 / 3
Arsenic	3 / 5	Ingestion* Inhalation*	3 / 5 3 / 5
Chromium	4 / 4	Inhalation*	1 / 4

(a) Constituents listed in this table are present in at least one sample at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Includes direct radiation from contaminated land and inhalation of radon decay products.

Exhibit 5-3
Potential Constituents of Concern in Coal Gas Ash Leachate[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/No. of Analyses for Constituent
Arsenic	35 / 59	Human Health* Resource Damage Aquatic Ecological	35 / 59 4 / 59 2 / 59
Lead	27 / 59	Human Health Resource Damage Aquatic Ecological	10 / 59 27 / 59 5 / 59
Silver	7 / 58	Human Health Resource Damage Aquatic Ecological	1 / 58 1 / 58 7 / 58
Selenium	19 / 59	Resource Damage Aquatic Ecological	2 / 59 2 / 59
Mercury	7 / 59	Aquatic Ecological	5 / 59
Chromium	10 / 59	Resource Damage Aquatic Ecological	1 / 59 1 / 59
Sulfate[(c)]	1 / 1	Resource Damage	1 / 1
Aluminum[(c)]	2 / 2	Aquatic Ecological	2 / 2
Molybdenum	3 / 3	Resource Damage	3 / 3
Barium	49 / 59	Resource Damage	2 / 59

(a) Constituents listed in this table are present in at least one sample at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. 'Human health' screening criteria noted with an "*" are based on 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP test results.

- Uranium-238 concentrations exceed the radiation screening criterion by a factor of almost 4, suggesting that the ash could pose an unacceptable radiation risk if the ash were used in an unrestricted manner (e.g., direct radiation doses and doses from the inhalation of radon could be unacceptably high if people were allowed to build homes on top of the ash or if the ash were used for construction purposes).

- Uranium-238, arsenic, and chromium concentrations in the ash may be present in concentrations that exceed the inhalation screening criteria. This suggests that if small particles from the ash are blown into the air in a high concentration (equal to the National Ambient Air Quality Standard for particulate matter), chronic inhalation of these constituents could cause a cancer risk exceeding 10^{-5}. As discussed in the section on release/transport/exposure potential, however, such large exposures to windblown particles are generally not expected at the Beulah facility.

- Thallium and arsenic may be present in the ash at concentrations that exceed the incidental ingestion screening criterion, suggesting that these constituents could pose health risks if small quantities of the ash are routinely ingested over a long period of time (i.e., more than about seven years). Arsenic concentrations could pose a cancer risk of greater than 1×10^{-5}, while thallium concentrations could cause adverse central nervous system effects.

Of the 24 constituents analyzed in the leach tests, the following 10 constituents are present at concentrations that exceed the screening criteria based on water pathway risks: arsenic, lead, silver, selenium, mercury, chromium, sulfate, aluminum, molybdenum, and barium. All of these constituents are inorganics that do not degrade in the environment. Arsenic, silver, and lead are of relatively greater concern because their concentrations in the ash leachate exceed the screening criteria with the greatest frequency and magnitude. Arsenic concentrations exceeded the human health (drinking water) screening criterion in almost 60 percent of the samples analyzed; the median arsenic concentration exceeded the criterion by a factor of 8, and the maximum exceeded by a factor of 1,100. Silver concentrations exceeded the aquatic ecological screening criterion in 12 percent of the samples, and the maximum silver concentration exceeded the criterion by a factor of 370. No other constituents are present in concentrations that exceed screening criteria by a factor of 10. In addition, no constituents were detected in concentrations that exceed the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of effects under the following conditions:

- If leachate from the ash were released to ground or surface water, and diluted less than tenfold during migration to a drinking water source, long-term chronic ingestion may cause adverse health effects due to the presence of arsenic, lead, and silver. The arsenic concentrations in the diluted ash leachate may pose a significant (i.e., $> 1 \times 10^{-5}$) lifetime cancer risk if ingested.

- Coal gasifier ash leachate contains arsenic, lead, silver, selenium, chromium, sulfate, molybdenum, and barium in concentrations that exceed the water resource damage screening criteria. This suggests that if leachate from the ash is released and migrates into ground or surface water with a tenfold dilution or less, the resulting concentrations of these constituents may be sufficient to restrict the potential future uses of the affected water (e.g., render stream water unsuitable for irrigation or for drinking water supply unless treated).

- Arsenic, lead, silver, selenium, mercury, chromium, and aluminum concentrations in the ash leachate exceed the aquatic ecological screening criteria, suggesting that these constituents may present a threat to aquatic ecological receptors if the leachate migrates (with less than 100-fold dilution) to streams, rivers, or lakes.

These exceedances of the screening criteria, by themselves, do not demonstrate that the ash poses a significant risk, but rather indicate that it may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the ash to cause significant impacts, EPA analyzed the actual conditions that exist at the sole facility that generates and manages the waste (see the following section on release, transport, and exposure potential).

Coal Gasification Process Wastewater Constituents of Potential Concern

Using the same process summarized above for gasifier ash, EPA identified constituents in coal gasification process wastewater that may present a hazard by collecting data on the composition of this waste, and evaluating the intrinsic hazard of the chemical constituents present in the process wastewater.

Data on Coal Gasification Process Wastewater Composition

EPA's characterization of the process wastewater and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW) and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, a number of other inorganic constituents (i.e., ammonia, ortho-phosphate, and phosphorus), and 159 organic constituents in total and leach test analyses.

Concentrations in total sample analyses of the process wastewater are consistent for most constituents across the two data sources. For antimony, however, the results differ significantly. EPA did not detect antimony in the wastewater at a detection limit of 0.025 mg/L while industry data show antimony to be present at concentrations almost five orders of magnitude higher. Concentrations from the two types of leach test analyses (i.e., EP and SPLP) of the process wastewater generally are similar. However, EP leach test data from the two sources -- 1989 OSW sampling and analysis and industry response to the RCRA §3007 request -- differ considerably (no SPLP data were provided by industry). Among the eight constituents for which EP leach test data are available from EPA and industry, four constituents (i.e., arsenic, chromium, mercury, and selenium) are detected in EPA analyses at concentrations that are one or two orders of magnitude higher than in industry analyses.

The following evaluation of constituents in the process wastewater is based on concentrations detected in total analyses of the wastewater. Leach test analyses are generally similar to total analysis results, although a smaller number of constituents in concentrations above the screening criteria are identified in the leachate (possibly because of the filtration step involved in leach test analyses). Several of the inorganic constituents with EP toxicity regulatory levels (arsenic, cadmium, chromium, lead, mercury, and selenium) were measured in higher concentrations in total analyses than leach test analyses.

Identified Constituents of Concern

Exhibit 5-4 presents the results of the comparisons of coal gasification process wastewater constituent concentrations to the screening criteria. This exhibit lists all constituents for which at least one sample concentration exceeds a relevant screening criterion.

Of the 182 constituents analyzed in the process wastewater, only 19 are present at concentrations that exceed the screening criteria: phosphorus, phosphate, antimony, mercury, arsenic, thallium, molybdenum, selenium, nickel, iron, copper, manganese, lead, cadmium, cobalt, chromium, acetonitrile, phenol, and pH. Seven of these -- phosphorus, phosphate, antimony, mercury, arsenic, thallium, and phenol -- were present in concentrations in the process wastewater that exceed the screening criteria with greatest frequency and magnitude (i.e., maximum concentrations of these constituents exceed a screening criterion by more than a factor of 10, and more than one-third of all samples analyzed for the constituent exceed the criterion). None of the constituents, however, were detected in concentrations above the EP toxicity regulatory levels, and the wastewater does not exhibit the hazardous waste characteristics of corrosivity, ignitability, or reactivity.

Exhibit 5-4
Potential Constituents of Concern in Coal Gas Process Wastewater (total)(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria(b)	No. of Analyses Exceeding Criteria/No. of Analyses for Constituent
Phosphorous	1/1	Aquatic Ecological	2/2
Phosphate	1/1	Aquatic Ecological	1/1
Antimony	2/3	Human Health Resource Damage Aquatic Ecological	2/3 2/3 2/3
Mercury	5/6	Resource Damage Aquatic Ecological	1/6 5/6
Arsenic	3/8	Human Health* Resource Damage	3/8 2/8
Thallium	2/3	Human Health	2/3
Molybdenum	2/3	Resource Damage	2/3
Selenium	5/8	Resource Damage Aquatic Ecological	5/8 1/8
Nickel	2/3	Human Health Resource Damage Aquatic Ecological	1/3 1/3 2/3
Iron	3/3	Resource Damage	2/3
Copper	3/3	Aquatic Ecological	2/3
Manganese	3/3	Resource Damage	1/3
Cobalt	2/3	Resource Damage	1/3
Lead	2/8	Human Health Resource Damage Aquatic Ecological	1/8 2/8 1/8
Cadmium	2/8	Human Health Resource Damage Aquatic Ecological	1/8 1/8 1/8
Chromium	9/10	Resource Damage	1/10
Acetonitrile	2/2	Human Health	2/2
Phenol	2/2	Resource Damage	2/2
pH	1/1	Resource Damage	1/1

(a) Constituents listed in this table are present in at least one sample at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

These exceedances of the screening criteria have the following implications:

- Antimony, arsenic, thallium, acetonitrile, nickel, lead, and cadmium may be present in seepage from the process wastewater surge pond at concentrations that exceed the human health screening criteria. This suggests that if the wastewater is released to useable ground or surface water, these constituents could cause adverse human health effects via long-term chronic ingestion of drinking water, if it is diluted by only a factor of 10 during migration to drinking water supplies. Exposures to arsenic in the diluted leachate could pose a lifetime cancer risk of greater than $1x10^{-5}$.
- Phenol, antimony, mercury, arsenic, molybdenum, selenium, nickel, iron, manganese, lead, cadmium, cobalt, and chromium are present in the process wastewater at concentrations that exceed the water resource damage screening criteria. This indicates that if the wastewater migrates into ground water with less than a 10-fold dilution or migrates into surface water with less than a 100-fold dilution, the resulting concentrations of these contaminants could render the water resources unsuitable for a variety of uses (e.g., drinking water, livestock watering, irrigation, consumption of fish that live in contaminated water bodies). The wastewater is also alkaline (pH 10) and could threaten water resources if it were to raise the pH of receiving waters to above 8.5 standard units.
- If process wastewater were released to nearby surface waters (with less than 100-fold dilution), phosphorus, phosphate, antimony, mercury, selenium, nickel, copper, lead, and cadmium could pose a risk to aquatic life.

As discussed above for coal gas ash, these exceedances of the screening criteria, by themselves, do not demonstrate that the process wastewater poses a significant risk, but rather indicate that the wastewater may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the wastewater to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facility that generates and manages the waste.

Release, Transport, and Exposure Potential

This section describes the actual release, transport, and exposure potential of the coal gasification wastes as they were generated and managed at the Beulah plant in 1988. For this analysis, the Agency did not assess the hazards of off-site use or disposal of the wastes, because the wastes are currently managed only on-site (although it is conceivable that ash with certain properties could be used off-site in the future in the manufacture of cement or concrete products). In addition, the following analysis does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on which to base forecasts of future conditions. Alternative practices for the management of gasifier ash and process wastewater are discussed in Section 5.5.

Ground-Water Release, Transport, and Exposure Potential

The waste characterization data discussed above indicate that leachate from the waste ash contains 10 constituents at concentrations that exceed the conservative screening criteria. Similarly, the characterization of the process wastewater identified 19 constituents that exceed the screening criteria. These wastes contain from 2 to 7 constituents that exceed screening criteria related to ground water by factors of at least 10, although no contaminants were detected in concentrations that exceed the EP toxicity regulatory levels. The constituents in the waste ash leachate and process wastewater that are expected to be readily mobile in groundwater are phosphorus, phosphate, mercury, molybdenum, selenium, cadmium, chromium, and sulfate.

Differences in the characteristics of the management units used to dispose of the gasifier ash and store process wastewater contribute to substantial differences in the potential ground-water hazards posed by these wastes as they are currently managed.

- The gasifier ash landfill has a liner of recompacted local clay, but does not have any other type of ground-water controls such as a leachate collection system.
- The surge pond that is used to temporarily store the process wastewater has multiple engineered controls to limit seepage to ground water. This pond has a double liner -- comprised of separate layers of synthetic material and recompacted local clay -- and has both primary and secondary leachate collection systems.

As a consequence of these controls, the potential for releases of process wastewater from the surge pond is limited to a large extent, while the potential for releases from the landfill is higher. In fact, ground-water monitoring data from the Dakota facility provides evidence that the ash landfill may be contributing to ground-water degradation. The Dakota facility reported that drinking water standards for nitrate, sulfate, chloride, pH, and total dissolved solids had been exceeded in downgradient monitoring wells. The facility attributes these exceedances to possible ambient ground-water quality problems in this area; Section 5.3.2 provides further discussion of these monitoring data.

The hydrogeologic characteristics at the site indicate a potential for contaminants to migrate into ground water: net recharge in the vicinity of the facility is moderate (10 cm/year), and ground water is very shallow (0.3 to 0.6 meters beneath the landfill). These factors, in combination with the relatively high leachability of the ash and the limited ground-water release controls at the landfill indicate a high potential for contaminants to migrate from the ash landfill into underlying ground water. The controls on the surge pond should significantly limit migration of the wastewater.

Although the facility reported that the aquifer underlying the facility is not being used for any purpose, mapping data indicate that there are two residences between 900 and 1,600 meters (1 mile) downgradient of the facility that appear to be located outside of areas covered by local water distribution systems, and, therefore, may rely on private water sources (e.g., private wells). Consequently, leachate from the landfill could damage the value of the aquifer as a potential resource, but the potential for current human exposures is low because of the large distance (> 900 meters) to the small population (i.e., two residences) that may rely on ground water downgradient of the site as a drinking water supply.

Surface Water Release, Transport, and Exposure Potential

In theory, constituents from the gasifier ash in the landfill or process wastewater in the surge pond could enter surface waters by (1) migration of leachate or seepage through ground water that discharges to surface water or (2) direct overland run-off of dissolved or suspended materials from the landfill or surge pond.

The potential for release and transport of gasifier ash and process wastewater contaminants to surface water appears limited by the relatively low precipitation in the area (37 cm/year), the presence of stormwater run-off controls designed to limit erosion from the landfill and overflow of the surge pond, and the gentle topographic slope (0 to 2 percent) that also limits erosion potential. In addition, while there is an on-site stormwater diversion ditch and a nearby intermittent stream, the facility is far removed from perennial water bodies that may be used: the nearest perennial stream is 10 km (6 miles) downslope and this stream discharges into the Knife River approximately 15 km away. Because the facility is not located in or near a 100-year floodplain, large episodic releases and subsequent overland transport due to flooding are also unlikely.

Despite these mitigating factors, releases to surface water from the ash landfill may have occurred. As discussed in Section 5.3.2, a State of North Dakota Notice of Violation indicates that gasifier ash management practices at this facility "probably resulted in some surface water degradation."[6] Although the notice does not clarify this statement, the degradation is likely confined to the on-site drainage ditch and nearby intermittent stream, potentially caused by either stormwater run-off or discharge of contaminated ground water from the landfill. These waters are unlikely to be used for human consumption, but any contamination in them potentially could be harmful to aquatic organisms.

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[6] North Dakota State Department of Health and Consolidated Laboratories. 1987. Interdepartmental Memorandum from S. Tillotson to B. Dellmore, through M. Schock, Re: ANG Notice of Violation. 7/20/87.

Should contamination from this site reach the distant Knife River or its tributary, either by overland run-off or through ground-water infiltration, the relatively large annual average flow (600 mgd) of the river could rapidly assimilate (dilute) the contamination. Consequently, contamination from gasifier ash and process wastewater appear to pose a minimal threat to potential uses of the river or to its aquatic life. To the best of the Agency's knowledge, no population currently relies on the river as a regular drinking water source in the vicinity of the Dakota facility, and no current human health risks from drinking water exposures are expected.

Air Release, Transport, and Exposure Potential

Air pathway risks from ash and process wastewater involve two different release pathways. The constituents that exceed the screening criteria in gasifier ash -- uranium-238, arsenic, and chromium -- are nonvolatile inorganics that can be released to air only as wind-blown particles (dust). Acetonitrile and phenol conceivably could pose inhalation risks through volatilization from the process wastewater. The concentrations of these constituents in the wastes represent relatively low human health risks (as indicated by relatively low ratios of the maximum concentrations to screening criteria).

Factors that determine the potential for inorganic constituents of the gasifier ash to be suspended in air are the particle size of the ash, the exposed surface area of the landfill, the moisture content of the ash, the use of dust suppression controls, and wind speeds in the vicinity of the facility. The potential for exposure to airborne contaminants depends on the distances from the landfill to nearby residences and the population in the area. In general, particles that are ≤ 100 micrometers (µm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are ≤ 30 µm in diameter can be transported for considerable distances downwind, and only particles that are ≤ 10 µm in diameter are respirable.

Although some fraction of the ash may exist as particles that can be suspended in air and cause airborne exposure and related impacts, the vast majority of the gasifier ash is comprised of particles too large to be suspended, transported, and respired. In addition to the generally large particle size, releases of the ash are also limited by dust suppression practices and the moisture content of the ash as it is deposited in the landfill. However, in the event that areas of the landfill surface become dry (e.g., if dust suppression is ceased or provides incomplete coverage), a small fraction of the ash particles could be blown into the air because of the large exposed area (approximately 5 hectares [12 acres]), the relatively small number of days with rain that may suppress dust (54 days/yr), and the strong winds in the area (4.5 to 6.7 m/s). After the small, near-surface particles are depleted, airborne emissions would again decline to low levels.

The ability of an organic constituent to volatilize from the wastewater depends on its Henry's Law constant, which is a measure of the constituent's tendency to partition between water and air. A large Henry's Law constant indicates a greater propensity for an organic compound to volatilize from water. Because acetonitrile and phenol have relatively high Henry's Law constants, they may be released from the surge pond by volatilization.

Evaluation of the location of potential exposure points indicates that the air pathway risks from these wastes are relatively small. Winds at the Dakota facility blow most frequently in the WNW, W, S, WSW directions. The nearest downwind residences in these directions are quite distant (i.e., 2.1, 1.5, 4.5, and 5.2 km, respectively) and the population within 8 kilometers (5 miles) in these directions is very sparse (i.e., 13, 18, 8, 18 people, respectively). The population within a radius of 80 km from the facility is approximately 40,000. Considering the low inorganic constituent concentrations relative to air pathway screening criteria, the low potential for release of dust from the landfill, and the great dispersion of airborne contaminants (both volatiles and particles) that would occur during transport to exposure points greater than one kilometer away, there is a low potential for human exposure (and associated health risk) to dust blown from the ash landfill or contaminants volatilized from the surge pond.

Proximity to Sensitive Environments

The coal gasification facility is not located in or near any environments that may facilitate contaminant release and transport (such as floodplains, karst, and fault zones), that have high resource value (such as National Parks), or environments that are especially sensitive to contaminant exposures (such as wetlands and endangered species habitat).

Risk Modeling Results

Based upon the evaluation of the intrinsic hazard of gasifier ash and process wastewater, both wastes contain a number of constituents in concentrations that may present a hazard under a very conservative set of hypothetical release and exposure conditions. However, considering the actual conditions that exist at the Beulah, ND facility, the potential for these wastes to cause significant human health or environmental impacts is low. This conclusion is based on the following findings:

- Only arsenic and silver in coal gasifier ash and its leachate are present at concentrations more than ten times the screening criteria; seven constituents in coal gas process wastewater exceed the conservative screening criteria by a factor of 10 or greater; but neither gasifier ash nor process wastewater exhibit any of the four characteristics of hazardous waste.
- The potential for releases from the ash landfill and surge pond are limited by controls such as liners, run-off controls, and dust suppression. Nevertheless, releases to ground- and surface water from the ash landfill have occurred. The potential for exposures to released contaminants at concentrations of concern is relatively low given the large distances to nearby residences and perennially flowing surface water.

This conclusion is supported by the information on documented damage cases (presented in the next section) and the Agency's risk modeling results for other wastes that appear to pose a greater hazard than the coal gasification wastes. Therefore, in accordance with the risk assessment methodology outlined in Chapter 2, the Agency has not conducted a quantitative risk modeling exercise for these wastes. Section 5.3.3 below discusses the basis for the assessment of moderate hazard in more detail.

5.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the performance of waste management practices for gasifier ash and process wastewater at Dakota Gasification's active facility in Beulah, North Dakota, and at two inactive coal gasification facilities: Ashland in South Point, Ohio; and Fairfield in Fairfield, Iowa.[7] The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found documented environmental damages associated with the gasifier ash management units at the Dakota Gasification facility.

Dakota Gasification Company, Beulah, North Dakota

The plant site is located on a broad valley that is underlain by the Antelope Valley or Beulah Trench aquifer. The Beulah Trench interconnects with the aquifer associated with the Knife River Valley, which serves as a water supply source for the communities of Beulah and Hazen, located approximately nine miles south and 14 miles southeast of the plant site, respectively. The mine used as the coal supply for the plant is located immediately east of the facility site.[8]

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[7] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

As described earlier in this chapter, ash from the gasifier is quenched (with blowdown from the wet scrubber system on the facility's incinerator) and sluiced into one of four ash sumps where the ash is settled from the slurry. The liquid recovered during the ash dewatering is recycled back to the ash quench and sluicing area or used as makeup water to the liquid waste incinerator. The dewatered ash is trucked to an on-site landfill.

The landfill area designated as SU-101 is currently the active portion of the landfill that receives gasifier ash. Large pits within the SU-101 area are utilized for the disposal of the gasifier ash and other waste streams. According to the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL), at least 90 percent of all waste disposed in SU-101 consists of gasifier ash. Excess liquids from the gasifier ash disposed in area SU-101 flows with any additional run-off to the adjacent sumps and may be later pumped to the evaporation pond. Analytical data from August 1989 show that the pH of water in the sump ranges from 12.7 to 13.7, while the arsenic concentration ranges from 13.8 mg/L to 22.0 mg/L, and the selenium concentration ranges from 1.1 mg/L to 2.2 mg/L.[9,10,11]

In December 1985, NDSDHCL expressed concerns to ANG (the former owner of the facility) regarding the levels of water in the run-off pond [sump] within the ash storage area, because of high pH and high arsenic content in the run-off water. The Department stated that the disposal of gas ash containing excess liquids must be discontinued immediately.[12]

In July 1987, NDSDHCL Division of Waste Management and Special Studies prepared a memorandum that summarizes letters written and inspections conducted relating to ANG's gasifier ash dewatering system and disposal area. This memorandum requested the issuance of a Notice of Violation to ANG for improper waste handling procedures relating specifically to the dewatering of gasifier ash, the unauthorized placement of associated liquids and sludges having potentially hazardous characteristics in the gasifier ash disposal area, and the spillage of ash, liquids and sludges during transport from the dewatering area to the ash disposal area. The memorandum discusses ANG's violations of the State's Solid Waste Management rules, including the unauthorized placement of liquid and semi-liquid wastes in a landfill not permitted for such wastes, the unauthorized improper construction and operation of the disposal site, the inadequate protection of surface water in violation of permit conditions, and the spillage of liquids, sludges, and ash during transport. As stated in the memorandum: "ANG's [practices have] . . . increased the potential for groundwater degradation and [have] probably resulted in some surface water degradation."[13]

According to the NDSDHCL, Dakota Gasification discontinued the use of unlined ponds for the disposal and storage of liquid bearing wastes in 1988. Ponds since mid-1988 have at least a clay liner. The most recently completed pond has a composite liner. The state also noted that although the liquid bearing wastes are still being disposed into a clay lined landfill, excessive run-off is directed into a pond with a composite liner.[14]

According to monitoring reports submitted by DGC to NDSDHCL presenting quarterly data from April 1988 to June 1989, monitoring wells around a portion of the landfill area indicated significant differences in downgradient wells as compared to upgradient wells. From five to six total samples taken from upgradient wells 15, 16, and 17, Electrical Conductivity (EC) averaged 4,790 μmhos/cm; sulfates (SO_4) averaged 1,248 mg/L; and total dissolved solids (TDS) averaged 3,638 mg/L. From eight total samples taken from downgradient wells, 14, 18 and 24, EC averaged 11,870 μmhos/cm; SO4 averaged 7,056 mg/L; and TDS averaged 11,569 mg/L.

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[8] North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL). 1989. Letter from S. Tillotson to C. Greathouse, Re: Dakota DGC SU-101. December 21.

[9] NDSDHCL. 1990. Personal Communication with S. Tillotson. January.

[10] Dakota Gasification Company. 1989. Letter from D.R. Guminski, Environmental Manager, to M. Shock, NDSDH. November 17.

[11] NDSDHCL. 1990. Letter from S. Tillotson to C. Greathouse, Re: DGC SU-101. February 20.

[12] NDSDHCL. 1985. Letter from M. Schock to G. Weinreich, ANG, Re: SU-049. With Attachments. December 12.

[13] NDSHDCL. 1987. Interdepartmental Memorandum from S. Tillotson to B. Dellmore, through M. Schock, Re: ANG Notice of Violation. July 20.

[14] NDSDHCL. 1990. Letter from S. Tillotson to K. McCarthy, ICF, Re: Dakota Gasification Company SU-101. May.

Monitoring well analytical data in a DGC report dated February 22, 1989, indicated that three additional wells near the ash disposal area had exhibited "increased concentrations" of some constituents. Analysis of samples from one of these wells revealed increased mean specific conductance (15,000 μmhos/cm), as well as increased mean concentrations of sodium (3,000 mg/L), sulfates (11,000 mg/L), and TDS (17,000 mg/L). Background, or upgradient data, were not provided. The other two wells contained similar concentrations, and over a period of one year or less, historical data document the increases in these constituent levels (Exhibit 5-5).[15]

5.3.3 Findings Concerning the Hazards of Coal Gasification Wastes

Based upon the detailed examination of the inherent characteristics of coal gasifier ash and process wastewater, the management practices that are applied to these wastes, the environmental setting in which the materials are managed, and the documented environmental damages that have been described above, EPA concludes that these wastes pose a low risk to human health and the environment.

Intrinsic Hazard of the Wastes

Review of the available data on constituent concentrations in gasifier ash and its leachate indicates that only arsenic and silver exceed one or more of the screening criteria by more than a factor of 10, though maximum concentrations of these two constituents exceed the screening criteria by a wide margin (1,100 in the case of arsenic and 370 in the case of silver). Based on one sample result, the concentration of uranium-238 exceeds the radiation screening criterion by almost a factor of four, suggesting that uranium and its decay products could pose an unacceptable radiation risk if the ash were used in an unrestricted manner. Combined with the fact that the ash does not exhibit any of the four hazardous waste characteristics, these findings lead EPA to conclude that the intrinsic hazard of this waste is low to moderate. These data also suggest that the documented ground-water contamination described above in Section 5.3.2, was caused, at least in part, by wastes other than gasifier ash that had been co-disposed in the ash landfill.

Exhibit 5-5
Increases in Concentrations of Selected Constituents in Two Gasifier Ash Disposal Area Monitoring Wells (1987 - 1988)

Well	Net Increase in Parameter Value Between Sampling Periods				
	Cl (mg/L)	SO_4 (mg/L)	Na (mg/L)	Spec. Cond. (μmhos/cm)	TDS (mg/L)
W04018	3,910	840	1,125	11,290	—
W04020	2,114	525	877	5,200	3,759

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[15] Dakota Gasification Company. 1989. Letter from A.C. Lukes to S. Tillotson, NDSDH, Re: Ground-water Monitoring Assessment Plan--SU-049. February 22.

Review of the available data on process wastewater constituent concentrations indicates that 19 constituents exceed one or more of the screening criteria and that seven exceed the criteria by more than a factor of 10. The available data also indicate that the waste does not exhibit any of the four hazardous waste characteristics. As a result, EPA believes that the intrinsic hazard of this waste is moderate.

Potential and Documented Dangers

Evaluation of the potential for release, transport, and exposure through the ground-water, surface water, and air pathways indicates that potential releases of contaminants in the process wastewater are limited by engineered release controls, and that improper construction and waste handling at the ash landfill has caused past releases to ground- and surface water. Nevertheless, the potential for current exposures to any released contaminants is low because of the relatively large distance from waste management units to potential exposure points.

Releases to ground water from the surge pond are unlikely because this unit is double-lined and has two leachate collection systems. In contrast, the documented case of danger to human health and the environment indicates that the design and operation of the ash landfill do not control the release of coal gasifier ash or other contaminants to ground water. Any ground-water contamination arising from the ash landfill at present, however, is unlikely to threaten human health or ground-water use given the relatively low levels of contamination in ash leachate, the current lack of use of ground water in the area, and the relatively large distance to existing downgradient residents where exposures could occur.

Releases from the process wastewater surge pond to surface water via ground-water discharge are limited by the ground-water controls mentioned above, and overland flow of surge pond overflow is limited by run-off controls. The damage case indicates that surface water degradation may have occurred due to ash management practices, but it is unlikely that contamination from the ash would pose significant threats to the Knife River or its tributaries given the large distance to the river and its perennial tributaries and the large flow of the river. Residual contamination in a drainage ditch and nearby intermittent stream, however, may adversely affect aquatic organisms living in these habitats.

Releases to air are limited by dust suppression at the landfill. In addition, any contaminants released in windblown ash or volatilized from the surge pond would pose a small risk because of the large distance (> 1 km) to the nearest residence in a predominant wind direction.

Conclusions

Based on the low to moderate degree of intrinsic hazard of the wastes, the limited potential for release, transport, and exposure via the ground-water, surface water, and air pathways, and the limited evidence of documented cases of danger to human health or the environment from current waste management practices, EPA concludes that the potential danger posed by coal gasifier ash and process wastewater from coal gasification is limited. Accordingly, the Agency has investigated current applicable regulatory requirements and alternative waste management and utilization, but has not examined in detail the costs and associated impacts of additional regulatory requirements.

5.4 Existing Federal and State Waste Management Controls

5.4.1 Federal Regulation

EPA is unaware of any specific Federal management control or pollutant release requirements that apply specifically to coal gasifier ash or process wastewater from coal gasification.

5.4.2 State Regulation

The single coal gasification facility addressed by this report is located in Beulah, North Dakota. The State of North Dakota excludes mineral processing wastes from its hazardous waste regulations, but classifies the coal gasification wastes generated at the Beulah facility as "special wastes" under the state's solid waste regulations. Under this approach, North Dakota currently regulates the disposal of gasifier ash by requiring that the landfill into which the ash is placed be permitted. Permit requirements include standards for liners, closure, and post-closure care. Unlike the landfill requirements, North Dakota has not required that the process wastewater pond at this facility be permitted. The state, however, did ensure that liners and other engineering controls were used by the facility in constructing the pond. North Dakota is in the process of amending its solid waste regulations, which as proposed would require the permitting of surface impoundments used for coal gasification process wastewater storage and management. The extent and nature of any additional technical criteria applied to these units or to gasifier ash landfills, however, cannot be predicted. Finally, although North Dakota's air pollution control rules include provisions for control of particulate matter releases from industrial processes, the air permit for the Beulah facility does not directly address the facility's waste management units.

5.5 Waste Management Alternatives and Potential Utilization

As noted above, the available data indicate that gasifier ash and process wastewater do not exhibit any of the characteristics of hazardous waste. Consequently, the issue of how a gasification facility might modify its operations or waste management practices or be stimulated to develop alternative uses for the ash in response to prospective hazardous waste regulation is moot. Nevertheless, this section provides a brief summary of current coal gas waste management practices and potential areas of utilization.

Coal Gasification Process Wastewater

The process wastewater has an average pH of 9.8 with approximately 0.2 percent solids. Instead of being used as make-up water for the cooling system, the process wastewater could be treated and discharged, although the practicality of this option is limited because the facility is located in a water short area. In addition, the wastewater could be treated to remove contaminants prior to use in the cooling system. This approach would be less efficient than current practices, however, because the efficiency with which contaminants can be removed from the wastewater generally increases with increasing concentration, and use of the wastewater in the cooling system increases the contaminant concentrations through evaporation.

Coal Gasifier Ash

Although none of the ash currently being generated is sold for commercial use, ash with sufficient pozzolanic properties could be used in the manufacture of cement and concrete products. However, the levels of uranium-238 and other contaminants make it uncertain whether utilization of the ash in this fashion would be adequately protective of human health and the environment. In addition, utilization requires an available market and it is not clear that a significant market exists near enough to the facility to be economical.

Alternative approaches to disposal would include installation of a synthetic liner and leachate collection system in the on-site landfill and run-off pond.

5.6 Cost and Economic Impacts

Because the available data indicate that gasifier ash and process wastewater do not exhibit any of the characteristics of hazardous waste, the issues of how waste management costs might change because of new requirements associated with regulation as hazardous wastes under RCRA Subtitle C for these wastes and what impacts such costs might impose upon affected facilities is moot. Consequently, no incremental costs or associated economic impacts would result from a decision to remove the mining waste exclusion for these wastes.

5.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Coal Gasifier Ash

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of coal gasifier ash is low to moderate as compared to other mineral processing wastes studied in this report. The ash does not exhibit any of the four characteristics of hazardous waste, and data on constituent concentrations in solid samples and laboratory leachate of the ash indicate that only two constituents are present in concentrations greater than 10 times the screening criteria used in this analysis. The ash, however, may contain uranium-238 and its decay products in concentrations that could pose an unacceptable radiation risk if the solids were allowed to be used in an unrestricted manner.

In addition to the relatively low to moderate intrinsic hazard of this waste, current management of the ash at the coal gasification facility in Beulah, North Dakota (the only facility addressed by this report) appears to limit the potential for the ash to threaten human health or the environment. Although there is the potential for release of constituents to ground water at the North Dakota facility, as evidenced by documented releases of contaminants to ground water underlying the ash landfill, the potential for significant risks resulting from drinking water exposure is low because of the relatively large distance from waste management units to potential exposure points. Similarly, threats to human health and the environment from releases to surface water are limited by the large distance to the nearest downgradient perennial streams and the relatively large flow of the Knife River. The release of contaminants to the atmosphere is limited by dust suppression measures at the landfill, and in any case, would pose a small risk because of the large distance to the nearest residence.

Environmental damages associated with the Dakota Gasification ash management facility have been documented by the State of North Dakota, and reveal that drainage from an ash landfill was observed to have pH values of 12.7 to 13.7, arsenic concentrations of 13.8 to 22.0 mg/L, and selenium concentrations of 1.1 to 2.2 mg/L. EPA believes, however, that these high levels are caused in large part by wastes other than the ash that were co-managed in the landfill, because leach test analyses of the ash by itself show significantly lower concentrations. In addition, as discussed above, the potential for significant exposures to this contamination appears low.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The relatively low to moderate intrinsic hazard of the waste and the waste, management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment are expected to continue in the future in the absence of more stringent federal regulation. The character of the ash is unlikely to change in the future, and despite the fact that the analysis of potential dangers is limited to the one active site at which the waste is currently managed, EPA believes that the conclusion of low hazard can be extrapolated into the future unless coal gasifier ash is managed in locations that are closer to potential exposure points. However, it is unlikely, for two reasons, that risks would occur at other locations in the future. First, without the kind of subsidy provided for the construction of the existing facility, it is unlikely that economic conditions would favor the construction and operation of new facilities in the near future. Second, gasifier ash is not currently used or disposed off-site, though there is a slight possibility that ash with certain properties could be used at alternate sites in the future for the manufacture of cement and concrete products.

The potential for increased risks from gasifier ash management in the future is further restricted by substantial State regulation of the ash landfill. North Dakota's regulatory program excludes gasifier ash generated at the Beulah facility from hazardous waste regulation, addressing it instead as a "special waste" under the State's solid waste rules. Under this approach, North Dakota currently regulates the disposal of gasifier ash by requiring that the landfill into which the ash is placed be permitted. Permit requirements include standards for liners and closure. The State is currently in the process of amending its solid waste regulations, though the likely effects of these amendments on coal gasifier ash management and disposal are not clear.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of gasifier ash, the general absence of documented damages associated with this material, and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating gasifier ash from coal gasification under RCRA Subtitle C.

Coal Gasification Process Wastewater

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of coal gasification process wastewater is moderate compared to other mineral processing wastes studied in this report. The process wastewater does not exhibit any of the four characteristics of hazardous waste. Data on constituent concentrations in the wastewater, however, indicate that seven constituents are present in concentrations that exceed the screening criteria used in this analysis by at least a factor of 10.

Although the intrinsic hazard of this wastewater is moderate, current management of the wastewater at the Dakota Gasification facility in North Dakota appears to limit the potential for this waste to threaten human health or the environment. Releases from the surge pond to surface or ground waters are considered unlikely because of the pond's double synthetic liner, leachate collection systems, and run-off controls. In addition, any contaminants released by the volatilization, seepage, or run-off of the process wastewater would pose little risk because of the large distance to potential exposure points.

The lack of documented cases of damage attributed to coal gasification process wastewater confirms that the waste, as currently managed, appears not to cause significant health or environmental impacts. Review of State and EPA Regional files and interviews of State and EPA Regional regulatory staff did not produce any evidence of documented environmental damages attributable to management of process wastewater at the active Dakota Gasification facility and two inactive coal gasification facilities.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The relatively low hazard posed by current management of coal gasification process wastewater is expected to continue in the future in the absence of Subtitle C regulation. The characteristics of this waste are unlikely to change in the future, and despite the fact that the analysis of potential dangers is limited to the Dakota Gasification facility, EPA believes that the conclusion of low hazard can be extrapolated into the future unless coal gasification process wastewater is managed in locations that are closer to potential exposure points or in ponds with less comprehensive release controls. However, it is unlikely that risks would occur at other locations in the future because construction of new gasification facilities is not foreseen and it is unlikely that the wastewater would be managed off-site.

The potential for increased risks from coal gasification process wastewater management in the future is further restricted by substantial State regulation of "special waste" management units. North Dakota's regulatory program excludes coal gasification process wastewater generated at the Beulah facility from hazardous waste regulation, addressing it instead as a "special waste" under the State's solid waste rules. The State has not required that the process wastewater ponds at this facility be permitted, though the State did ensure that liners and other engineered controls were adopted in the construction of the surge pond. North Dakota is currently in the process of amending its solid waste regulations, which would require the permitting of process wastewater surge and cooling ponds, though the extent of permit requirements and their effect on the management and disposal of the wastewater is not clear.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of process wastewater from coal gasification and the absence of documented damages associated with this material and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating process wastewater from coal gasification under RCRA Subtitle C.

Chapter 6

Primary Copper Processing

The domestic primary copper processing industry analyzed in this report consists of ten facilities that, as of September 1989, were active and reportedly generating one or more of the following mineral processing special wastes: slag (i.e., smelter, converter, and/or anode furnace slag), slag tailings, or calcium sulfate sludge from wastewater treatment. These ten primary processing facilities[1] conduct a variety of smelting and refining operations, including electrolytic refining.[2] The data included in this section are discussed in additional detail in a technical background document in the supporting public docket for this report.

6.1 Industry Overview

The majority of the copper consumed in the U.S. is used in the electrical industry. It is used for a wide range of wiring applications (from power transmission lines to printed circuit boards), in microwave and electrical tubes, motors and generators, and many other specialized applications where its high electrical and thermal conductivity can be employed. While copper has been replaced in some applications by aluminum (e.g., for overhead power lines) and fiber optics (e.g., in telecommunications), its durability, strength, and resistance to fatigue assure its continued use in the electrical industry. These latter three characteristics also make copper and copper alloys a valued material in construction and containment (e.g., pipes and tanks), and in other applications where endurance and resistance to corrosion are required.[3]

The ten facilities in this study consist of four primary smelting and fire-refining facilities; four primary smelting, fire-refining, and electro-refining facilities; and two primary fire and electro-refining facilities, as shown in Exhibit 6-1. These facilities are located in five states, with nine of the ten facilities located in the Southwest. The dates of initial operation for these facilities range from 1912 to 1984; the average age is approximately 33 years. Most of the facilities have undergone modernization; the most recent in 1989. The total annual primary copper smelting production capacity is approximately 1.27 million metric tons per year of anode copper; the primary copper refining capacity is about 1.33 million metric tons per year of refined copper.

Primary production of copper in the U.S. has steadily increased throughout the late 1980s. Between 1986 and 1989, production from domestic and imported materials increased by 38 percent. Imports of refined copper for consumption have decreased by 40 percent (from 502,000 metric tons to 300,000 metric tons) since 1986, while exports have increased 833 percent (from 12,000 metric tons to 100,000 metric tons). Total apparent consumption has risen slightly from 2,136,000 metric tons in 1986 to 2,250,000 metric tons in 1989.[4] Several companies have announced plans for improvements and expansions of existing facilities or opening new facilities in the early 1990s that would further increase the supply of copper coming from the U.S. ASARCO plans to expand its mining capacity and to employ a new flash smelting process at its El Paso, Texas facility.[5] Kennecott has announced plans to increase production at its Utah copper operation by 32,000

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[1] In addition to the 10 primary facilities, several secondary processing facilities are operating; the operations conducted at these facilities, however, fall outside the definition of primary mineral processing and, thus, do not generate special mineral processing wastes.

[2] At least seven additional facilities concentrate copper at stand-alone electrowinning operations. These are, however, considered beneficiation operations, as long as they do not use as primary feedstock, materials that have undergone mineral processing operations, e.g., smelting and refining, (see 54 FR 36592, September 1, 1989). These facilities, their operations, and the wastes that they generate are not within the scope of this report.

[3] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 206-7.

[4] Janice Jolly and Daniel Edelstein, U.S. Bureau of Mines, Mineral Commodity Summaries, 1990 Ed., p. 52.

[5] Tim O'Neil, "ASARCO: Plant Expansions and Modernizations Continue Amidst Company Restructuring," Mining Engineering, June 1989, p. 430.

Exhibit 6-1
Primary Copper Processing Facilities

Owner	Location	Presence of Operation Type		
		Smelter and Converter	Anode Furnace	Electrolytic Refinery
ASARCO	Amarillo, TX	No	Yes	Yes
ASARCO	El Paso, TX	Yes	Yes	No
ASARCO	Hayden, AZ	Yes	Yes	No
RTZ/Kennecott	Garfield, UT	Yes	Yes	Yes
Copper Range	White Pine, MI	Yes	Yes	Yes
Cyprus	Claypool, AZ	Yes	Yes	Yes
Magma	San Manuel, AZ	Yes	Yes	Yes
Phelps Dodge	El Paso, TX	No	Yes	Yes
Phelps Dodge	Hurley, NM	Yes	Yes	No
Phelps Dodge	Playas, NM	Yes	Yes	No

metric tons per day.[6] Finally, Mitsubishi has announced its intention to build a smelter at Texas City, Texas that would produce 150,000 metric tons of blister copper per year.[7]

The demand for copper is closely tied to the overall economy, and demand has remained relatively flat through the late 1980's. Future demand depends upon the health of the economy in the 1990s. Almost 40 percent of the 1988 U.S. consumption of copper went to the building and construction industries, while about 23 percent was used by the electrical and electronic industries. Industrial machinery and equipment, the power generation industry, and the transportation industry together consumed 38 percent of the copper produced in 1988.[8] Clearly, the development of new infrastructure in the U.S. and abroad would increase the worldwide demand for copper, but consumption per unit of new gross product would be less than that in the past because substitutes for copper are often used in a number of industries. For example, new telephone infrastructure is being based upon fiber optic technology rather than copper to a significant degree.[9] Continued re-opening of mothballed copper facilities, expansion of existing facilities, and development of new mines could lead to copper supplies increasing faster than demand.[10]

As seen in Exhibit 6-2, primary copper production operations include, in general, smelting, converting, fire refining in an anode furnace, and electrolytic refining. The products from each operation, respectively, are copper matte, blister copper, copper anodes, and refined copper. The term "copper smelting" is sometimes used to refer to the combined operations of smelting (in reverberatory, electric, or flash furnaces), converting, and often, when co-located, fire refining. For purposes of this report, smelting will refer to the initial step, in which the concentrate is first fused (i.e., heated to a point above the melting point of the mineral value).

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[6] "Kennecott Expanding Utah Copper," E&MJ, February 1990, p. 14.

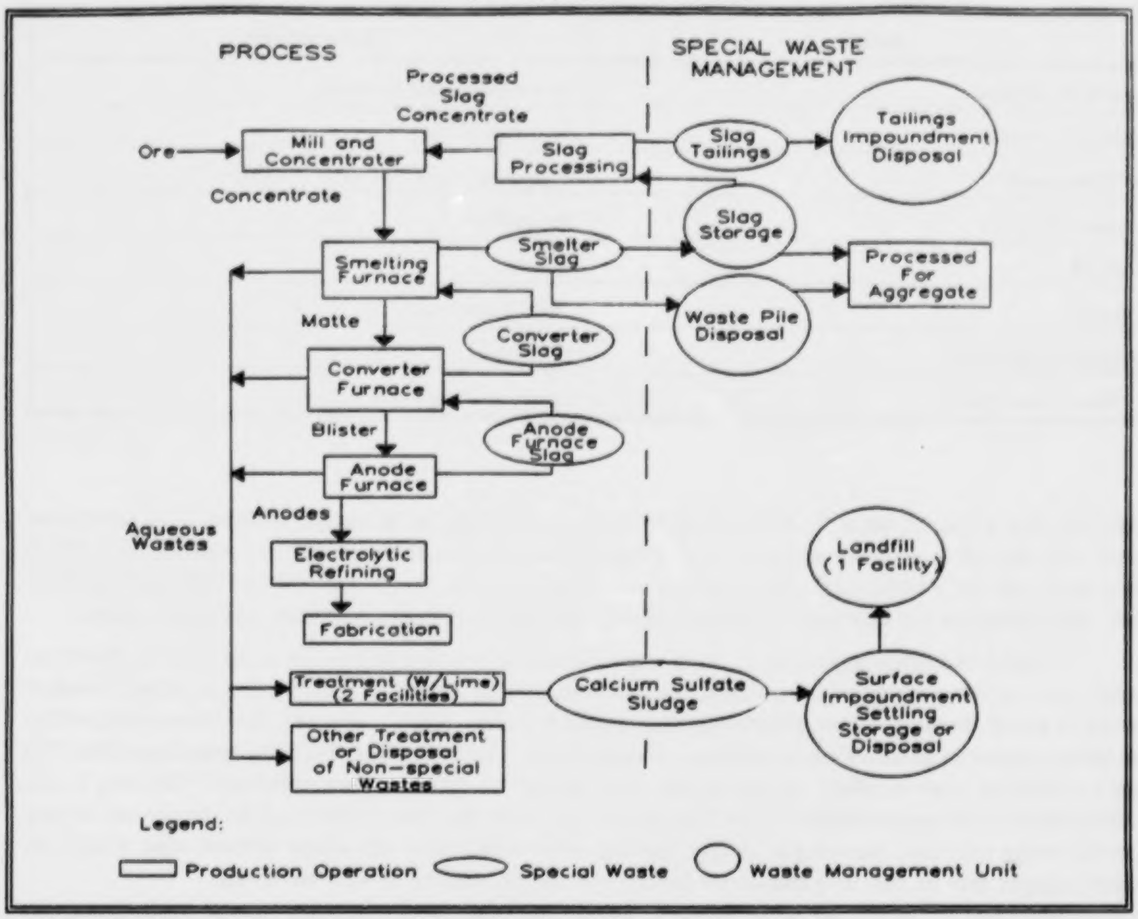
[7] Simon D. Strauss, "Copper: 1989 Was a Good Year; 121st Annual Survey and Outlook," E&MJ, March 1990, p. 19.

[8] "Copper's Future is as Clear as the Economy," E&MJ, January 1990, p. 15.

[9] Ibid.

[10] Ibid.

Exhibit 6-2
Primary Copper Processing


PROCESS
SPECIAL WASTE MANAGEMENT
Processed Slag Concentrate
Ore
Mill and Concentrator
Slag Processing
Slag Tailings
Tailings Impoundment Disposal
Concentrate
Slag Storage
Smelting Furnace
Smelter Slag
Processed For Aggregate
Waste Pile Disposal
Matte
Converter Slag
Converter Furnace
Blister
Anode Furnace Slag
Anode Furnace
Anodes
Aqueous Wastes
Electrolytic Refining
Fabrication
Landfill (1 Facility)
Treatment (W/Lime) (2 Facilities)
Calcium Sulfate Sludge
Surface Impoundment Settling Storage or Disposal
Other Treatment or Disposal of Non-special Wastes
Legend:
Production Operation
Special Waste
Waste Management Unit

Smelting involves the application of heat to a charge of copper ore concentrate, scrap, and flux, to fuse the ore and allow the separation of copper from iron and other impurities. Several types of smelting furnaces are in use in the U.S., as shown in Exhibit 6-3. In all operations the furnaces produce two separate molten streams: copper-iron-sulfide matte and slag. The smelter slag, a special waste, is essentially a mixture of flux material, iron, and other impurities; the slag is typically hot dumped (i.e., poured into a storage/disposal pit or pile while still molten) and air cooled or cooled with water, or cooled with water (granulated) prior to dumping. The slags from some smelting furnaces are higher in copper content than the original ores taken from the mines. These slags, therefore, may be sent to a concentrator and the concentrate returned to the smelter. The waste portion of this slag processing operation is the second special waste, slag tailings from primary copper processing. Three facilities report reprocessing their slag, thereby generating slag tailings, a special waste.

The copper matte from the smelter furnace is typically routed hot to the converter furnace; some facilities have actually combined these operations. In either case, a high-silica flux and compressed air or oxygen are introduced to the molten matte. Most of the remaining iron combines with the silica to form

Exhibit 6-3
Summary of Furnace Types

Facility	Furnace Type
ASARCO, El Paso	Reverberatory (with pre-roast)
ASARCO, Hayden	Flash (Outokumpu)
RTZ/Kennecott	Noranda Reactor (Continuous Process)
Copper Range	Reverberatory
Cyprus	Electric
Magma	Flash (Outokumpu)
Phelps Dodge/Hurley	INCO Flash
Phelps Dodge/Playas	Electric and Flash (Outokumpu)

converter slag, a special waste.[11] After removing the slag, additional air or oxygen is blown in to oxidize the sulfur and convert the copper sulfide to blister copper that contains about 99 percent copper; the sulfur is removed in the form of SO_2 gas, which reports to an acid plant where it is converted to high grade sulfuric acid. Depending on the efficiency of the acid plant, some amount of SO_2 is emitted to the atmosphere.

Oxygen and other impurities in blister copper must be removed before the copper can be fabricated or cast into anodes for electrolytic refining. Blister copper is fire refined in reverberatory or rotary furnaces known as anode furnaces; all ten facilities operate anode furnaces. When co-located, the furnace may receive the blister copper in molten form so remelting is unnecessary. Air is blown in to oxidize some impurities; flux may be added to remove others. A slag is generated during this anode furnace operation. This slag is also a component of the special waste.[12] The final step in fire refining is the reduction of the copper and oxygen removal using reformed natural gas of logs (poting) while it is still in the anode furnace, after which the molten copper may be cast into anodes for further electrolytic refining or wire-rod forms.

Electrolytic refining, the final refining operation, does not directly generate a special waste and is not described in detail for this report. Along with the operations described above, however, electro-refining does produce various aqueous waste streams (e.g., process wastewater, bleed electrolyte) that must be treated and discharged, reused, or disposed in some manner. Many of the facilities use a wastewater treatment operation to treat these wastes. Two of the ten facilities, the Hayden, AZ and Garfield, UT facilities, use a treatment process employing lime as an additive to neutralize the wastewaters and precipitate dissolved metals. The solid residual from these treatment operations is a calcium sulfate sludge, which is the third special waste generated by the primary copper sector.

6.2 Waste Characteristics, Generation, and Current Management Practices

The three special mineral processing wastes generated by copper processing operations, slag, slag tailings, and calcium sulfate wastewater treatment sludge, are discussed separately below.

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[11] Most if not all converter slag is recycled directly back to the smelter. When this occurs, this recycled material is not a solid waste (see 40 CFR Part 261).

[12] Most if not all anode furnace slag is recycled directly back to the converting furnace. When this occurs, this recycled material is not a solid waste (see 40 CFR Part 261).

6.2.1 Slag from Primary Copper Processing

Slag from the smelting, converting, and anode furnaces is generated at eight of the ten facilities; the other two facilities (in Amarillo and El Paso) do not have smelting operations and produce only small quantities of anode furnace slag. Waste characteristic and generation rate data typically have not been reported for converter and anode furnace slag, as the slags are directly recycled. Because of the difference in generation rates and management of smelter slag versus converter and anode furnace slag (i.e., nearly all converter and anode furnace slag is recycled), smelter furnace slag is discussed separately from converter and anode slags.

Smelter Slag

Smelter slag is molten when tapped from the reactors and solidifies into a glassy, rock-hard mass upon cooling. When crushed, pieces of the copper slag may range in size from gravel to boulder, or even larger. The SWMPF Surveys describe the slag as a solid; typically gravel or cobble sized; and composed primarily of iron silicates, calcium oxide, and alumina (aluminum oxide), with small amounts of copper, lead, zinc, and other metals. The specific gravity of the slag is usually between 3.0 and 3.5.[13]

In 1988, the eight active smelters generated approximately 2.5 million metric tons of smelter slag. On an individual facility basis, the quantity generated at the six smelters that provided non-confidential data ranged from about 165,000 to nearly 500,000 metric tons. The smelter slag to copper anode production ratio is approximately 2.2 (i.e., 2.2 metric tons of smelter slag are generated for every ton of copper anode produced).

At all eight copper smelters, smelter slag is initially deposited on waste piles. In five cases, the waste piles are for temporary storage. At three of these five facilities, the slag is subsequently processed in a concentrator and the resulting concentrate is returned to the smelter. At another facility, the slag is moved to a pile at the edge of a tailings pond for disposal, and at the fifth, the slag is, in part, sold. At the three remaining facilities, the slag is disposed of in the waste piles and remain there indefinitely.

Three smelters process all their smelter slag either in their ore concentrator (San Manuel and White Pine) or, in the case of the Utah facility, in a stand-alone slag concentrator. The process streams resulting from this operation are slag tailings, discussed below as a separate special waste, and a copper concentrate which is sent to the smelter as feedstock. Information on the stockpiles of smelter slag at two of these facilities was not reported. At the White Pine facility, the slag is dumped in a slag pile covering 24 hectares (60 acres) and 3 meters (10 feet) in height, from which the slag is periodically removed and sent to the concentrator. This slag dump has accumulated as of 1988, 1.36 million metric tons of slag; having been used as a disposal unit for some years. In 1988, however, more slag was removed from the dump for slag processing (212,000 metric tons) than was generated from the smelter (165,000 metric tons).

The temporary slag pile at the ASARCO/El Paso facility which, in 1988 sold its slag, is much smaller in comparison to the disposal piles, with a basal area of 0.9 hectares (2.1 acres) and 6 meters (20 feet) high; 450,000 metric tons of slag had accumulated as of 1988.

Four facilities (Hayden, AZ, Claypool, AZ, Playas, NM and Hurley, NM) dispose of all or part of the slag in on-site slag piles or slag dumps. The Claypool facility disposes of its slag in a pile at the edge of a tailings pond. As of 1988, the basal area of these slag piles ranged from 7 to 26 hectares (17 to 64 acres), and the height from 6 to 45 meters (20 to 150 feet.) The amount of slag accumulated in any one of these slag piles ranges from 2.7 to 20.9 million metric tons.

Using available data on the composition of copper smelter slag, EPA evaluated whether the slag exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, EPA does not believe the slag is corrosive, reactive, or ignitable, but some slag may exhibit the characteristic of EP toxicity. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for copper smelter slag from seven of the ten facilities of interest. Of these constituents, cadmium and lead concentrations, in one sample from just one facility (Phelps Dodge at Playas, NM), were found to exceed the EP regulatory levels. Cadmium was present at concentrations in excess of 8.5 times the regulatory level, in one of 70 samples. Likewise, lead concentrations exceeded the EP regulatory level in one of 68 samples, by a factor of roughly three. Because the slag samples that failed the EP toxicity test were not analyzed using the SPLP leach test, it is not clear if cadmium and lead concentrations would have exceeded the EP toxicity levels if the SPLP test had been used.

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[13] Collins, R.J. and R.H. Miller, Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis, FHWA-RD-76-106, prepared for Federal Highway Administration, May 1976, p. 113.

Converter and Anode Furnace Slag

Approximately 380,000 metric tons of converter and anode slag are generated annually, ranging from nearly 29,000 to just over 244,000 metric tons for the six non-confidential facilities with smelting operations; the one non-confidential electrolytic refinery generated only 1,200 metric tons of anode furnace slag.

The primary management practice for both the converter and anode furnace slag is recycling. The eight facilities that have smelters and, therefore, converter operations, all recycle their converter slag back to the smelter furnace and their anode furnace slag back to their converter. ASARCO/Amarillo and Phelps Dodge/El Paso each operate a stand-alone refinery with an anode furnace; both ship their anode furnace slag back to one of their two company-owned smelters for resmelting. Temporary waste piles are used to store the slag before it is shipped off-site.

6.2.2 Slag Tailings from Primary Copper Processing

Slag tailings from primary copper processing is a solid material, typically composed of particles smaller than sand, that is settled from a slurry. Only three facilities, those in Michigan, Utah, and San Manuel, AZ, presently send their smelter slags to a concentrator and thereby generate slag tailings. At the Michigan and San Manuel, AZ facilities, the same concentrator is used for both ore and slag, so the slag tailings and ore tailings are co-generated. The Utah facility has separate concentrators for the ore and slag, but the slag tailings and ore tailings are mixed prior to disposal. The primary constituents in slag tailings reportedly are silicon, iron, magnesium, sodium; smaller amounts of copper, lead, and zinc; and other trace elements.

Non-confidential waste generation rate data were provided to EPA by all three facilities generating slag tailings. The aggregate annual industry-wide generation of slag tailings by the three plants was approximately 1.5 million metric tons in 1988, yielding a facility average of nearly 504,000 metric tons per year. Individual facility generation rates ranged from 206,000 to nearly 969,000 metric tons. The average waste-to-product tonnage ratio (i.e., slag tailings to copper anode) for the three facilities was 1.4 in 1988.

Slag tailings are co-managed in on-site tailings ponds with tailings from ore beneficiation at all three facilities. One facility, located in Michigan, has five tailings ponds on-site, while the other two facilities (in Utah and Arizona) each have a single tailings pond. These ponds cover anywhere from 142 to 2,270 hectares (352 to 5,600 acres) each. Industry-wide, these ponds cover a total area of 4,400 hectares, yielding a facility-specific average of approximately 600 hectares. On average, the ponds are roughly 46 meters (150 feet) deep (depth may range from 16 to 61 meters).

The combined amount of slag tailings accumulated at all seven ponds, as of 1988, is approximately 12.6 million metric tons. The average quantity of slag tailings accumulated in each pond is roughly 1.8 million metric tons, although it could range from 241,000 to 3.4 million metric tons. At all three facilities, slag tailings constitute a relatively minor portion of the total tailings (slag plus ore/mill tailings) held in each of the tailings ponds. Slag tailings at the Michigan plant range from 0.2 to 3.5 percent of the total tailings in the five ponds. At the other two facilities, slag tailings are 0.3 and 2.6 percent of the total tailings managed in the ponds.

Data available to EPA from site sampling visits and responses to a RCRA §3007 request, as well as professional judgment, indicate that slag tailings do not exhibit any of the characteristics of hazardous waste (i.e., ignitability, reactivity, corrosivity, or EP toxicity) at any of the facilities that generate the waste. These data identify the concentrations of all eight inorganic EP constituents in slag tailings samples from two of the three facilities (Garfield and San Manuel) that generate this waste. Using the EP leach test, all eight constituents were measured in concentrations that were at least two orders of magnitude below the EP-toxicity regulatory levels -- that is, below primary drinking water standards.

6.2.3 Calcium Sulfate Wastewater Treatment Plant Sludge From Primary Copper Processing

Calcium sulfate sludge is generated only by the facilities in Hayden, AZ, and Garfield, Utah from lime treatment of wastewaters (e.g., acid plant blowdown). At the Utah facility, the sludge reportedly consists primarily of calcium sulfate (70 percent), with between 0.1 and 0.5 percent copper, zinc, and lead. Additional metals are present in trace amounts.[14] The total annual generation of calcium sulfate sludge is estimated to be approximately 140,000 metric tons per year and the average waste-to-product (smelter output) ratio is 0.42.[15]

The waste management practice used at both facilities is accumulation of the sludge solids in an on-site impoundment. At the Utah facility, two on-site surface impoundments are used for sludge storage. Both impoundments have a surface area of about 2.2 hectares (5.5 acres); one impoundment is 2.3 meters (7 feet) deep and the other is 3 meters deep. One impoundment is used to accumulate sludge, while sludge previously accumulated in the second ("inactive") impoundment is allowed to dry prior to dredging. The air-dried sludge in the inactive impoundment is dredged and stabilized, and then disposed in a landfill that is located in a designated area within the on-site tailings impoundment.

The Hayden, AZ facility also accumulates its calcium sulfate slurry in an on-site surface impoundment. In 1988, approximately three percent of the sludge was dredged from the impoundment and recycled to the flash furnace; the remainder was left to accumulate in the impoundment, which has an area of 3.35 hectares (8 acres) and is 3.2 meters (10 feet) deep. The impoundment has an asphalt/rubber liner and run-on/run-off controls; no leachate or wind dispersal controls are used.

Using available data on the composition of calcium sulfate wastewater treatment plant sludge, EPA evaluated whether the waste exhibits any of the four hazardous waste characteristics: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, EPA does not believe that this waste is corrosive, reactive, or ignitable, but it does exhibit the characteristic of EP toxicity. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for one of the two facilities of interest (Garfield). Of these constituents, arsenic, cadmium, and selenium concentrations were found to exceed their respective regulatory levels. Concentrations of arsenic and selenium exceeded EP-toxicity regulatory levels in all of the seven samples analyzed, by factors as high as 140 and 14, respectively. Cadmium concentrations exceeded the EP-toxicity threshold in six of the seven samples, by as much as four times the regulatory level. On the other hand, SPLP leach test concentrations of metals with EP-toxicity limits were below the EP-toxicity regulatory levels for all of the samples analyzed.

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[14] According to the EPA waste sampling and analysis data, the sludge from primary copper processing contains copper (0.154%), lead (0.144%), arsenic (0.117%), iron (0.0351%), zinc (0.0232%), aluminum (0.0157%), and smaller amounts of antimony, barium, beryllium, cadmium, cobalt, mercury, manganese, molybdenum, nickel, selenium, silver, thallium, and vanadium.

[15] One of the two respondents to EPA's 1988 survey indicated that the quantity of calcium sulfate sludge generated was confidential. As a result, the estimated average quantity presented here is based on alternative data sources as discussed in the technical background document.

6.3 Potential and Documented Danger to Human Health and the Environment

In this section, EPA discusses two of the study factors required by Section 8002(p) of RCRA for wastes generated in the copper processing sector: (1) potential risk to human health and the environment associated with the management of copper slag, copper slag tailings, and calcium sulfate sludge generated at copper processing plants; and (2) documented cases in which danger to human health and/or the environment has been proven. Overall conclusions about the hazards associated with each of the three wastes are based on the Agency's evaluation of these two factors.

6.3.1 Risks Associated With Copper Slag

Any potential danger to human health and the environment from copper slag is a function primarily of the composition of the slag, the management practices that are used, and the environmental settings of the facilities where the slag is generated and managed. These factors are discussed separately below, followed by EPA's risk modeling results for this waste.

Constituents of Concern

EPA identified chemical constituents in copper slag that may present a hazard by collecting data on the composition of slag, and evaluating the intrinsic hazard of chemical constituents present in the slag.

Data on Copper Slag Composition

EPA's characterization of copper slag and its leachate is based on data from three sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); (2) industry responses to a RCRA §3007 request in 1989; and (3) sampling and analysis conducted by EPA's Office of Research and Development (ORD) in 1984. These data provide information on the concentrations of 21 metals and a number of inorganic constituents (i.e., phosphorus, fluoride, sulfate, and nitrate) in total and/or leach test analyses, and represent samples from all 10 facilities that generate copper slag.

Concentrations in total (solid) samples of the copper slag are consistent for most constituents across all data sources and facilities. Arsenic and nickel concentrations, however, varied over three orders of magnitude across the facilities.

Concentrations of constituents from leach test analyses of the copper slag generally are consistent across the data sources, types of leach tests (i.e., EP, SPLP, and TCLP), and facilities. In the EP analyses, however, chromium, zinc, and lead concentrations varied over approximately three orders of magnitude across the facilities.

Process for Identifying Constituents of Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the data summarized above to determine if copper slag or slag leachate contain any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing the constituent concentrations to screening criteria and then by evaluating the environmental persistence and mobility of constituents present in concentrations above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which the slag constituents are released to the environment and migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and water resources (see Exhibit 2-3). Given the conservative (i.e., protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Concern

Exhibits 6-4 and 6-5 present the results of the comparisons for copper slag (total) analyses and leach test analyses, respectively, to the risk screening criteria. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Of the 24 constituents analyzed in copper slag solids, arsenic, copper, lead, chromium, antimony, silver, and nickel are present at concentrations exceeding the screening criteria (see Exhibit 6-4). Among these constituents, arsenic, copper, and lead appear to pose the greatest potential threat because they were detected in most (73 to 98 percent) of the samples analyzed, their concentrations in most (61 to 73 percent) analyses exceed screening criteria, and their concentrations in samples from at least 5 of the 9 facilities exceed the screening criteria. In addition, only arsenic, copper, and lead exceeded the screening criteria by more than a factor of ten. All of these constituents are persistent in the environment (i.e., they do not degrade).

Exhibit 6-4
Potential Constituents of Concern in Copper Slag Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Arsenic	31 / 42	Ingestion* Inhalation*	31 / 42 26 / 42	6 / 9 5 / 9
Copper	44 / 45	Ingestion	28 / 45	5 / 9
Lead	41 / 43	Ingestion	31 / 43	6 / 9
Chromium	6 / 15	Inhalation*	3 / 15	3 / 8
Antimony	26 / 43	Ingestion	9 / 43	2 / 9
Silver	37 / 50	Ingestion	25 / 50	2 / 9
Nickel	21 / 27	Inhalation*	2 / 27	1 / 9

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

Exhibit 6-5
Potential Constituents of Concern in Copper Slag Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Lead	46 / 69	Human Health Resource Damage Aquatic Ecological	15 / 69 37 / 69 12 / 69	6 / 10 7 / 10 6 / 10
Copper	14 / 14	Human Health Resource Damage Aquatic Ecological	2 / 14 2 / 14 13 / 14	2 / 8 2 / 8 8 / 8
Arsenic	24 / 70	Human Health* Resource Damage	24 / 70 2 / 70	7 / 10 1 / 10
Molybdenum[c]	1 / 2	Resource Damage	1 / 2	1 / 2
Cadmium	46 / 71	Human Health Resource Damage Aquatic Ecological	6 / 71 8 / 71 7 / 71	5 / 10 5 / 10 5 / 10
Mercury	7 / 69	Aquatic Ecological	3 / 69	2 / 9
Iron	12 / 14	Resource Damage	2 / 14	2 / 8
Barium	28 / 70	Human Health Resource Damage	[illegible] / 70 [illegible] / 70	1 / 10 1 / 10
Chromium	20 / 71	Resource Damage Aquatic Ecological	1 / 71 1 / 71	1 / 10 1 / 10
Manganese	5 / 14	Resource Damage	1 / 14	1 / 8
Zinc	14 / 14	Aquatic Ecological	1 / 14	1 / 9

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP leach test results.

These exceedances indicate the potential for the following types of impacts under the following conditions:

- Arsenic, copper, lead, and to a lesser extent, antimony and silver concentrations exceed the ingestion criteria. This indicates that, if the slag (or soil contaminated with the slag) is incidentally ingested on a routine basis then constituents may cause adverse health effects. The concentration of arsenic in the slag would pose a lifetime cancer risk of greater than 1×10^{-5} if incidentally ingested.
- Arsenic, chromium, and nickel concentrations exceed the health-based screening criteria for inhalation. This indicates that these constituents could pose a cancer risk greater

than 1×10^{-5} if slag dust were blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter.

Based on a comparison of leach test concentrations of the 24 constituents to the surface and ground-water pathway screening criteria (see Exhibit 6-5), 11 contaminants were detected in concentrations above the criteria. Lead, copper, arsenic, molybdenum, and cadmium are present in concentrations that exceed at least one screening criterion in samples from at least 50 percent of all facilities at which they were analyzed. The other six constituents are present in concentrations that exceed the screening criteria in samples from no more than two of eight facilities. Maximum lead, copper, and arsenic concentrations exceed the screening criteria by more than a factor of 100, and maximum concentrations of molybdenum, cadmium, and mercury exceed the criteria by more than a factor of 10. The other constituents exceed the criteria by less than a factor of 10. As discussed in Section 6.2.1, the only constituents that were measured in concentrations that exceed the EP toxicity regulatory levels were cadmium (in 1 of 70 samples) and lead (in 1 of 68 samples).

- Concentrations of lead, copper, arsenic, cadmium, and barium in copper slag leachate exceed health risk (drinking water) screening criteria. This indicates that, if slag leachate were released and diluted by only a factor of 10 during migration to a drinking water exposure point, long-term ingestion could cause adverse health effects due to the presence of these constituents. The concentration of arsenic in diluted slag leachate could pose a cancer risk of greater than 1×10^{-5}.
- Lead, copper, cadmium, mercury, chromium, and zinc in the slag leachate may present a threat to aquatic organisms if it migrates (with a 100-fold dilution) to surface waters.
- Lead, copper, arsenic, molybdenum, cadmium, iron, barium, chromium, and manganese in the slag leachate, if released and diluted by a factor of 10 or less, could restrict the potential future uses of affected ground- and surface water resources.

These exceedances, by themselves, do not indicate that the slag poses a significant risk, but rather indicate that the slag may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the slag to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the slag.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of copper slag as it was generated and managed at the 10 plants of concern in 1988. For this analysis, the Agency did not assess the hazards associated with variations in waste management practices or potentially exposed populations in the future because of a lack of information adequate to predict future conditions. In addition, the following analysis does not consider the risks of off-site disposal or use of the slag because the slag is disposed of only on-site. Although one facility does sell its slag for off-site use and there is a potential for wider use of the slag in the future, insufficient information about the conditions of off-site use is available to support a detailed assessment of risks. Alternative slag management practices are discussed, however, in Section 6.5.

Ground-Water Release, Transport, and Exposure Potential

EPA and industry test data discussed above indicate that several constituents are capable of leaching from copper slag in concentrations that exceed the screening criteria. However, considering the existing slag management practices and neutral pH of the leachate, the only slag contaminants that are expected to be mobile in ground water if released are arsenic, molybdenum, cadmium, and to a lesser extent, barium and chromium. Exhibit 6-6 summarizes the key factors at each copper facility that affect the potential for these constituents to be released into ground water and cause impacts through that pathway.

Exhibit 6-6
Summary of Release, Transport, and Exposure Potential for Copper Slag

Facility	Release, Transport, and Exposure Potential for Copper Slag	Proximity to Sensitive Environments
AMARILLO[*]	**Ground water**: Although moderate recharge (10 cm/year) and permeable subsurface (80 percent sand), useable aquifer very deep (73m below facility) and thus somewhat protected. **Surface water**: No permanent water body within 1.6 km; a nearby playa lake could be contaminated by shallow ground-water discharge, but water is present only intermittently; when present, water may be used for livestock watering. **Air**: Small number of wet days (66 days/year) and high wind speeds (6.6 m/s) could lead to airborne dust and inhalation exposures at closest residence 760 meters from the facility; sparse population (5 people) within 1.6 km.	Not located in or near any sensitive environments
ASARCO/EL PASO	**Ground water**: Temporary slag management area has no engineered ground-water controls and ground water is shallow (3-6 meters), but releases are limited by low precipitation (20 cm/year) and very low net recharge (0.5 cm/year); no drinking water wells within 1.6 km of the facility. **Surface water**: Overland releases to the Rio Grande River have been documented (damage case); high potential for episodic overland releases to nearby river (76 meters) because of steep topographic slope (6-12%) and the facility is located in a 100-year floodplain; river has large flow (520 mgd) that yields significant dilution; drinking water intake 4 km downstream (500,000 people served). **Air**: Releases not controlled by dust suppression; small number of wet days (41 days/year) that may suppress dust and wind speeds up to 5.1 m/s could lead to airborne dust and inhalation exposures at closest residence 90 meters from the facility; population within 1.6 km is 500.	Located in a 100-year floodplain
HAYDEN	**Ground water**: Waste pile is not lined, annual precipitation is moderate (50 cm/year) and subsurface is slightly permeable; very low net recharge, i.e., 1.3 cm/year, creates low potential for releases to shallow ground water located roughly 6 m below the land surface; ground water does not appear to be used for any purpose. **Surface water**: Routine overland releases to nearby Gila River (located 80 meters from the facility) limited by stormwater runon/runoff controls and the gentle (0-2%) topographic slope in the area; low potential for releases to surface water via seepage to ground water; no consumptive uses of the river within 24 km; moderate flow of the river (170 mgd) allows moderate dilution, and therefore, possible ecological risks. **Air**: Releases not controlled by dust suppression; small number of wet days (47 days/year), large exposed area of the pile, and wind speeds up to 4.8 m/s could lead to airborne dust and inhalation exposures at closest residence 90 meters from the facility; population within 1.6 km is 2,200.	Not located in or near any sensitive environments

[*] No information is available on the slag management units at these sites. The information presented here is based only on the environmental setting of the facility.

Exhibit 6-6 (continued)
Summary of Release, Transport, and Exposure Potential for Copper Slag

Facility	Release, Transport, and Exposure Potential for Copper Slag	Proximity to Sensitive Environments
WHITE PINE	Ground water: High potential for releases to ground water due to absence of engineered controls, moderately shallow depth to aquifer (6-12 meters), high precipitation (73 cm/year), and relatively high net recharge (18 cm/year); no drinking water wells within 1.6 km of the facility. Surface water: Large annual precipitation and moderate topographic slope (up to 6%) together create potential for surface erosion and overland runoff to a stream located 120 m from facility; however, slag pile equipped with stormwater run-on/run-off controls surface water monitoring has indicated exceedances of drinking water and ambient water quality standards; episodic overland releases due to sudden snow-melt (maximum snow accumulation is 94 cm/storm) and releases to surface water via seepage to ground water could occur; stream has low dilution capacity (42 mgd); potential drinking water exposures could occur from a water supply intake 5 km downstream. Air: Dust suppression is not practiced but moderate number of wet days (116 days/year) could control airborne dust; wind speeds up to 4.7 m/s have the potential for producing airborne dust that could lead to potential airborne exposures at closest resident 730 meters from the facility; population within 1.6 km is 1,200.	Located in a Fault Zone and close to a National Forest
GARFIELD*	Ground water: Releases to useable ground water limited by low precipitation (40 cm/year) and net recharge (0.7 cm/year) and large depth to the aquifer (90 meters) that is overlain with clay; however, monitoring shows ground water contamination has occurred; contamination has not been attributed to copper slag; no drinking water wells within 1.6 km. Surface water: Episodic overland releases to the Great Salt Lake (300 m from facility) could occur due to a flood-event or sudden snow-melt (maximum snow accumulation is 102 cm); routine overland releases and releases via seepage to ground water are of lesser concern; low potential for exposure because the lake is not used for drinking water. Air: Releases not controlled by dust suppression; small number of wet days (89 days/year) and wind speeds up to 4.9 m/s could lead to airborne dust; significant potential for inhalation exposure because population within 1.6 km is 10,000.	Located in a 100-year floodplain and in a wetland

* No information is available on the slag management units at these sites. The information presented here is based only on the environmental setting of the facility.

Exhibit 6-6 (continued)
Summary of Release, Transport, and Exposure Potential for Copper Slag

Facility	Release, Transport, and Exposure Potential for Copper Slag	Proximity to Sensitive Environments
SAN MANUEL*	**Ground water**: No information is available on the ground-water controls at the temporary cooling pits for the slag that is recycled; releases to uppermost useable aquifer are significantly limited by large depth to the useable aquifer (140 meters), moderate precipitation and zero net recharge, and presence of an intervening layer of impervious lake-bed deposits; closest drinking water well is located 150 m from the facility. **Surface water**: Some potential for surface erosion because moderate precipitation (50 cm/year), moderate topographic slope (up to 6%) of the area, and moderate distance to nearby San Pedro River (790 meters); very low dilution capacity (0.06 mgd) of the stream could lead to ecological risks; no public water supply intake within 24 km of the facility, but there is an intake for livestock watering 1.2 km downstream. **Air**: No information is available on dust suppression controls at the slag cooling pits; airborne releases could be possible due to small number of wet days (47 days/year) and average wind speeds up to 4.8 m/s; potential inhalation exposures could occur at closest residence 330 meters from the facility; population within 1.6 km is 5,000.	Not located in, or near, any sensitive environments
PHELPS DODGE/ EL PASO	**Ground water**: Low potential for releases to ground water because of low precipitation (20 cm/year), very low net recharge (0.5 cm/year), large depth to aquifer (76 m), and presence of an asphalt liner beneath the temporary slag pile; no drinking water wells within 1.6 km downgradient of the facility. **Surface water**: Overland releases are limited by stormwater runon/runoff controls and low precipitation; given low potential for ground-water contamination, very unlikely that contaminants could migrate via ground water into Gila River located 550 m away; contaminants pose low risks to aquatic receptors because the river has a large dilution capacity (515 mgd); no consumptive uses of the river within 24 km. **Air**: Releases not controlled by dust suppression; small number of wet days (41 days/year) and average wind speeds up to 5.1 m/s could lead to airborne dust and inhalation exposures at closest residence 30 meters from the facility; significant exposures could occur because population within 1.6 km is 40,000.	Located in a Fault Zone
HURLEY	**Ground water**: Ground water monitoring has indicated contamination, but the contamination has not been attributed to copper slag; although no engineered ground-water controls and permeable subsurface, the low net recharge (5 cm/year) and large depth to ground water (30 m) help to limit releases from copper slag; potential exposures could occur at drinking water well <100 meters downgradient of the facility boundary. **Surface water**: There are no surface water bodies within 24 km of the facility. **Air**: Releases not limited by dust suppression controls; small number of wet days (50 days/year) and average wind speeds up to 4.3 m/s could lead to airborne dust and inhalation exposures at closest residence 6 meters from the facility; population within 1.6 km is 5,500.	Located in a 100-year floodplain, Fault and Karst Zones

* No information is available on the slag management units at these sites. The information presented here is based only on the environmental setting of the facility.

Exhibit 6-6 (continued)
Summary of Release, Transport, and Exposure Potential for Copper Slag

Facility	Release, Transport, and Exposure Potential for Copper Slag	Proximity to Sensitive Environments
PLAYAS	Ground water: Potential for release to shallow aquifer (4 m) is limited by low precipitation (26 cm/year) and zero net recharge; potential for exposure is minimal because closest drinking water well is more than 5 km downgradient. Surface water: Low potential for surface erosion because of low precipitation and gentle topographic slope of the area; seepage of contaminants to ground water that may discharge into the nearby (480 m) Playas Lake is also limited; lake water is not used for human consumption but is used for livestock watering. Air: Releases not limited by dust suppression controls; small number of wet days (40 days/year) and average wind speeds up to 5.3 m/s could lead to airborne dust; however, potential for inhalation exposures is relatively low because the closest residence is approximately 3.7 km from the facility, and there is no population within 1.6 km.	Located in a Fault Zone, and within 9 miles of an endangered species habitat
CLAYPOOL	Ground water: Releases are not limited by any engineered ground-water controls; standing liquid over some part of the slag in the tailings pond provides a leaching medium; contaminants could leach into the permeable subsurface (high percentage of sand); aquifer is very deep (91 to 116 m); potential drinking water exposures could occur at municipal well 1.2 km downgradient (approximately 9500 people rely on this well). Surface water: The closest surface water (Salt River) is 24 km away. Air: Release not limited by dust suppression controls; small number of wet days (43 days/year) that could suppress dust and average wind speeds up to 3.4 m/s could lead to airborne dust and inhalation exposure at closest residence 60 meters from the facility; population within 1.6 km is 1,000.	Located in a Fault Zone and close to a National Forest

* No information is available on the slag management units at these sites. The information presented here is based only on the environmental setting of the facility.

Seven of the 10 facilities in this sector provided information on their copper slag management units and it appears that, industry-wide, engineered ground-water controls are very limited. In addition to engineered controls, the potential for contaminant releases to ground water and subsequent transport to exposure points is determined by a number of site-specific factors, such as depth to ground water, precipitation and net recharge, the presence of intervening confining layers/aquifers, and the distance to downgradient drinking water wells. Considering these factors, the potential for contaminants to migrate into ground water is high at two facilities (White Pine and Hurley) and the potential for exposure to this contamination appears high at one facility (Hurley). The potential for contaminant migration and exposure at the other facilities is low to moderate, as summarized below.

- At the ASARCO/El Paso, Playas, and Phelps Dodge/El Paso facilities, the potential for slag contaminants to infiltrate into the underlying aquifers is significantly limited by low precipitation (20 to 26 cm/year) and very low net recharge (0 to 0.5 cm/year). Furthermore, the slag pile at the Phelps Dodge/El Paso facility is lined with asphalt, which provides limited control, and the ground water at this site is very deep (76 meters). Even if ground-water releases were to occur at these facilities, the potential for current drinking water exposures is low because there are no known downgradient drinking water wells within 1.6 km (1 mile) of the facilities.

- Ground-water releases from the slag piles at Claypool and Hayden due to infiltrating rainwater are also limited by low net recharge (i.e., 1 to 2.5 cm/year) at these facilities. At the Claypool facility, because a part of the slag is submerged in liquids, there may be a greater potential for contaminants to leach into the subsurface, but the useable aquifer at this facility is very deep (at least 91 meters below the land surface) and thus somewhat protected. If there is a release, current drinking water exposures are possible at Claypool because a large number of people (9,500) rely on a municipal drinking water well 1.2 km downgradient of the facility. According to the Hayden facility's survey response, ground water is not used for any purpose within 1.6 km (a mile) of the facility.

- The potential for releases from the slag piles to ground water is relatively high at White Pine and Hurley. At the White Pine facility, high rainfall (73 cm/year) and high net recharge (18 cm/year) indicate that, despite the clay layer beneath the waste pile, some amount of seepage from the pile could migrate to the moderately shallow aquifer (6 to 12 meters deep). Current drinking water exposures are unlikely at this facility because, to the best of EPA's knowledge, there are currently no downgradient wells within mile. Releases to ground water could, nevertheless, restrict the potential future uses of the aquifer. Although net recharge at the Hurley facility is small (5 cm/year) and the ground water is relatively deep, the permeable subsurface (60 percent sand, 30 percent silt) may allow leachate caused by infiltrating rainwater to migrate to ground water. Once in ground water, any contamination could migrate in a largely undiluted and unretarded fashion in solution cavities that may exist in the karst underlying the site. Potential drinking water exposures could occur at the nearest downgradient well located less than 100 meters from the Hurley facility.

Using only data on environmental settings, EPA evaluated the ground-water release, transport, and exposure potential of the three facilities that did not provide information on their slag management units. Based on limited data, it appears that the ground-water release, transport, and exposure potential is low at these three facilities.

- At San Manuel, releases to ground water from the slag are not likely because there is essentially no recharge to the aquifer at this location.

- At the Garfield facility, factors that limit the formation and migration of leachate from the slag management unit to the uppermost useable aquifer include the relatively low precipitation (40 cm/year) and net recharge (0.7 cm/year), and the large depth to the useable aquifer (90 meters) that is overlain by clay. The potential for current human health impacts from ground-water contamination is expected to be minimal because, to the best of EPA's knowledge, there are currently no drinking water wells in the useable aquifer within 1.6 km (1 mile) downgradient of the facility. Shallow ground water is hydraulically connected to the Great Salt Lake and is highly saline (not useable). Any leachate from the slag, however, could restrict the potential future uses of the aquifer as a resource.

- At the Amarillo facility, there is a potential for contaminants to migrate into shallow ground water because there is a moderate net recharge (10 cm/yr) and permeable subsurface. However, the potential for drinking water exposure is low because the useable aquifer is very deep, 73 meters below the facility.

Surface Water Release, Transport, and Exposure Potential

Constituents from copper slag could, in theory, enter surface waters by migration of slag leachate through ground water that discharges to surface water, or direct overland (stormwater) run-off of dissolved or suspended slag materials. The concentrations of several constituents detected in copper slag leachate tests (lead, copper, arsenic, molybdenum, cadmium, and to a lesser extent, mercury, iron, barium, chromium, manganese, and zinc) confirm that the potential exists for slag contaminants to migrate into surface water in a leached form. The potential for overland release of copper slag particles to surface waters is limited considerably by the generally large size and the glassy form of the slag: the solidified mass of slag as well as the large chunks of crushed slag are not readily eroded. A small fraction of the slag material, however, may consist of fragments that are small enough to be erodible. Only particles that are 0.1 mm or less in size tend to be appreciably erodible,[16] and only a very small fraction of the copper slag solids are expected to be in this size range.

Exhibit 6-6 summarizes the characteristics of each of the ten copper facilities that affect the surface water release, transport, and exposure potential of copper slag. Based on environmental settings of the facilities and the presence of stormwater run-on/run-off controls at the copper slag management units, the potential for surface water contamination and human exposure due to releases from copper slag at the ten facilities can be summarized as follows:[17]

- Copper slag piles at Claypool and Hurley have a low potential for causing surface water contamination because the facilities are very far from any streams, rivers, or lakes (at least 24 km).
- At Phelps Dodge/El Paso and Playas, overland releases are limited by low precipitation and gentle topographic slopes in the areas, as well as stormwater run-off controls at Phelps Dodge/El Paso. Episodic releases are not of concern because neither facility is located in a 100-year floodplain or in areas prone to high snow accumulation and sudden snow-melts. Given the very low potential for ground-water contamination at these sites, it is very unlikely that any contaminants originating from on-site slag management units could seep through ground water and discharge into the Rio Grande river located 550 meters from Phelps Dodge/El Paso or Playas Lake located 480 meters from the Playas facility.
- The potential for overland releases to surface water at the Hayden facility is limited by moderate rainfall (50 cm/year), gentle topographic slope, and the presence of stormwater run-on/run-off controls. Releases to the nearby Gila River could occur, however, by seepage of contaminants to the surficial aquifer that may discharge to the river, although there appears to be a low potential for shallow ground-water contamination at this facility (see above). Because the river has a moderate flow rate (170 mgd), any seepage entering the river will be only moderately diluted. The potential for human

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[16] As indicated by the soil erodibility factor of the USDA's Universal Soil Loss Equation.

[17] For three facilities that did not provide information on their temporary slag storage or slag cooling units, the copper slag was assumed to be temporarily accumulated in relatively small slag piles or pits. This assumption may have the effect of overestimating risks because releases are controlled solely by environmental conditions under this scenario.

exposures to any surface water contamination caused by the Hayden facility is currently minimal because the Gila River is not used for drinking water within 24 km downstream.

- Assuming there are no stormwater run-on/run-off controls at the San Manuel facility's slag pits, there is a potential for overland releases to the San Pedro River located 790 meters away because of the moderate rainfall (50 cm/year) and moderately steep slope (2 to 6%) in the area. Releases via seepage of contaminants through ground water are not expected because there is essentially no recharge to ground water. Any surface water contamination that is not sufficiently diluted could threaten aquatic life and restrict potential beneficial uses of the river because the river's low flow rate (0.08 mgd) will not rapidly dilute contaminants. Currently, there are no drinking water intakes from the river within 24 km.

- At the Amarillo facility, it is possible for slag contaminants to migrate through shallow ground water that may discharge to a nearby playa lake because of the moderate rainfall, moderate net recharge, and permeable subsurface in the area (i.e., factors that enable leachate from the slag pile to migrate to shallow ground water). Routine and episodic overland releases are less likely because the rainfall is moderate, and the facility is not located in a 100-year floodplain. Water is present in the lake only intermittently, but when present, the water may be used for livestock watering.

- The Garfield facility is located approximately 300 meters from the Great Salt Lake. Routine overland releases of slag contaminants to the lake are limited by the gentle topographic slope (0 to 2%) and the relatively low amount of precipitation in the area (40 cm/year). Episodic overland releases could occur, however, in the event of a flood (the facility is located in a 100-year floodplain) and sudden snow-melt (maximum snow accumulation is 102 cm). It is also possible for slag contaminants to reach the lake by seeping through ground water, although the potential for contaminant migration via ground water appears low. Any releases to the Great Salt Lake from the slag at this facility have a low potential for adversely affecting human health because the lake is not used for drinking water.

- The potential for release to surface water is relatively high at the ASARCO/El Paso facility; overland releases from the slag piles to the Rio Grande river (76 meters from the facility) have been documented (see damage cases section). Any contaminants reaching the river are likely to be diluted in the river's large flow (520 mgd). If sufficient dilution did not occur, the contamination could threaten aquatic life and the potential beneficial uses of this river, as well as pose human health risks, because there is a drinking water intake that serves almost 500,000 people approximately 4.3 km downstream of the facility.

- The potential for release of contaminants to surface water is also relatively high at the White Pine facility. Releases via seepage of contaminants through ground water could occur at White Pine because, as discussed above, some seepage from the pile could migrate to the shallow aquifer that probably discharges to the river. Although unlikely, episodic overland releases to the nearby river located 120 meters from the facility could also occur due to sudden snow-melts because the facility is located in an area with high snow accumulation (94 cm maximum). Routine overland releases, however, are limited by stormwater run-on/run-off controls and the moderate precipitation (73 cm/year) and slope in the area. Current human exposures to any surface water contamination caused by the White Pine facility are possible because there is an intake at a point 5.5 km downstream.

Air Release, Transport, and Exposure Potential

Because all of the constituents of concern are nonvolatile, copper slag contaminants can only be released to air in the form of dust particles. Dust can be either blown into the air by wind or suspended in air by slag dumping and crushing operations. Factors that affect the potential for such airborne releases include the particle size of copper slag, the height and exposed surface area of the slag piles, the slag moisture content, the use of dust suppression controls, and local wind speeds. The potential for exposure to airborne dust depends on the proximity of the slag piles to people.

The form of copper slag -- a solidified glassy mass that, even when crushed, consists of large particles such as gravel or cobbles -- significantly limits the potential for release of airborne dust. In general, particles that are $\leq$100 micrometers (μm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$30 μm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$10 μm in diameter are respirable. The vast majority of copper slag is substantially larger than 100 μm and thus should not be suspendable, transportable, or respirable. It is likely that only a very small fraction of the slag will be weathered and aged (or crushed) into smaller particles that can be suspended in air and cause airborne exposures and related impacts.

Other factors that affect the potential for airborne release and exposure vary on a site-specific basis, though not to a large extent, as follows:

- At the Hayden, Hurley, and Claypool facilities, the slag piles range from approximately 6.9 to 30 hectares (17 to 64 acres) in area and are 12 to 46 meters high. These piles are not covered with either vegetation or a synthetic material, and the facilities do not use any dust suppression controls, such as sprinkling water on the piles. The number of days with rain, which may suppress dust, is also small (43 to 50 days/yr). As a result, the surfaces of the slag piles are expected to be dry most of the time. Although there are surely short term gusts of stronger winds, average wind speeds at these facilities range from 3.4 to 4.8 m/s, which are strong enough to produce wind erosion of any fine particles. Any windblown dust could lead to potential exposures at Hayden, Hurley, and Claypool because at all three facilities, the nearest residence in a predominant wind direction is less than 100 meters away and the population within 1.6 km (1 mile) ranges from 1,000 to 5,500.
- At the Playas facility, the potential for airborne release is similar to the three facilities discussed above. However, the potential for exposures is lower because the nearest residence is 3.7 km away and there is no population within 1.6 km.
- The slag pile at the White Pine facility covers an area of 60 acres, is 3 meters high, and is uncovered. Although the pile is not currently watered for the purpose of dust suppression, there is a moderate number of days that have a small amount of precipitation (116 days/yr) that should help keep the slag moist part of the time. Average wind speeds range up to 4.7 m/s, though stronger winds occur on a short term basis. If airborne dust is released, it could lead to potential exposures at the nearest residence 730 meters from the facility, and could result in 1,200 people within 1.6 km (1 mile) of the facility being exposed.
- At the Asarco/El Paso and Phelps Dodge/El Paso facilities, the slag piles are relatively small (6 and 1 meter high, covering 0.8 hectares and 809 m^2 (2 and 0.2 acres)), making the exposed area of the piles much smaller than the piles at the other facilities. Nevertheless, the small number of days of precipitation to help keep dust down (41 days/yr) and average wind speeds of up to 5.1 m/s, which are strong enough to produce wind erosion of any fine particles, could allow airborne dusting. Both facilities have a residence within 100 meters of their boundaries where potential exposures could occur. There are 40,000 people living within 1.6 km (1 mile) of the Phelps Dodge plant and roughly 500 people within this distance of the Asarco facility.

- For the three facilities that did not provide information on their slag management units (Garfield, San Manuel, and Amarillo), factors such as low number of days of precipitation (47 to 89 days/yr) and average wind speeds of 4.8 to 6.6 m/s, which are strong enough to blow fine particles into the air, indicate that airborne releases could occur. All three facilities have a residence within 1.6 km (1 mile) of their borders where potential exposures could occur. The potential for exposure is highest at Garfield (which has 10,000 people within 1.6 km and the nearest residence located 900 meters away) and at San Manuel (which has 5,000 people within 1.6 km and the nearest residence located 330 meters away). At the Amarillo facility, on the other hand, there are only 5 people within 1.6 km of the facility and the nearest residence is 760 meters away.

Proximity to Sensitive Environments

As summarized in Exhibit 6-6, seven of the ten copper facilities that generate copper slag are located in or near environments that are either vulnerable to contamination or have high resource value.

- The Playas facility is located within 9 miles of a habitat for an endangered species, the New Mexico Ridge-Nosed Rattlesnake. Given this distance from the site, releases of copper slag contaminants from the facility are not likely to affect this habitat.
- The Asarco/El Paso, Garfield, and Hurley facilities are located in 100-year floodplains, which creates the potential for large, episodic releases caused by flood events (although such releases are generally unlikely).
- The Garfield facility is located in a wetland area (defined here to include marshes, swamps, and bogs). Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural waters, provide flood and storm damage protection, and afford a number of other benefits.
- The Hurley facility is located in an area of karst terrain, characterized by sinkholes and underground cavities developed in water-soluble rock (such as limestone or dolomite). Solution cavities could permit any ground-water contamination originating from the on-site slag to migrate in a largely unattenuated and undiluted fashion.
- The White Pine facility is located in a National Forest, and the Claypool facility is located within a mile of a National Forest. Any contamination originating from slag at these sites could have an adverse effect on the habitats and resources provided by these forests.
- The White Pine, Claypool, Phelps Dodge/El Paso, Hurley, and Playas facilities are located in fault zones. This creates the potential for damage to containment systems for slag piles at these sites in the unlikely event of an earthquake.

Risk Modeling

Based on the preceding analysis of the intrinsic hazard of copper slag and the potential for slag contaminants to be released into the environment, the Agency ranked copper slag as having a relatively high potential to cause human health and environmental risks (compared to the other mineral processing wastes studied in this report). Therefore, the Agency used the model "Multimedia Soils" (MMSOILS) to estimate ground-water, surface water, and air pathway risks caused by the management of copper slag. Rather than model all ten sites that generate and manage the slag individually, EPA modeled a hypothetical composite site that consists of selected features from three different sites. In particular, EPA modeled:

- The median constituent concentrations in copper slag solids as measured at the facility at Garfield, UT, and the median constituent concentrations in copper slag leachate as measured at the facility in Playas, NM. In general, the concentrations of most constituents measured in the slag and slag leachate at these facilities were higher than those measured at other facilities. The median concentrations at Garfield and Playas, however, are only slightly greater than the medians observed elsewhere and thus reasonably represent copper slag across the industry.

- The slag quantity, management practice, and environmental/exposure setting at the facility in White Pine, MI. Of the ten facilities that generate and manage the slag, this facility maintains one of the largest slag piles and has environmental and exposure characteristics most likely to lead to high risks. These characteristics include the highest net recharge of all ten sites, a relatively shallow water table, a useable aquifer beneath the site, a relatively nearby and small stream that may be used for drinking water, and relatively nearby residents that could be exposed to windblown dust. Although the slag pile at White Pine is equipped with stormwater run-on/run-off controls, EPA conservatively modeled the pile as if it had no controls to limit erosion.

By combining these generally typical waste stream contaminant concentrations with a set of "conservative" environmental and exposure characteristics into one modeling scenario, the Agency believes that the risk estimates presented below represent a reasonable upper bound of actual risks at the ten active primary copper facilities.

Ground-Water Risks

Using the combined site features as described above, EPA modeled potential releases to ground water from a hypothetical copper slag pile. EPA considered in this analysis the potential releases of arsenic, cadmium, chromium, and molybdenum, which are the primary constituents of potential concern through the ground-water pathway based on the analysis of copper slag leachate. In addition, EPA modeled the risks caused by potential releases of lead to ground water, because along with cadmium, lead was detected in EP leach tests in concentrations that exceeded the EP toxicity criterion. The Agency predicted the concentrations of these constituents at the following locations downgradient from the slag pile: the facility property boundary (150 meters), the nearest surface water body (120 meters), and, to analyze how far a contaminant plume might spread, the distances of 50 and 500 meters. At each of the locations, the Agency compared the predicted contaminant concentrations to cancer risk levels, threshold concentrations that could cause noncancer effects, drinking water maximum contaminant levels (MCLs), and guidelines for irrigation and livestock waters recommended by the National Academy of Sciences (NAS).

All of the Agency's predicted concentrations of arsenic, cadmium, chromium, molybdenum, and lead in ground water were at least two orders of magnitude below the various criteria, even at the closest point modeled (50 meters downgradient from the slag pile). The predicted concentration of arsenic in ground water 50 meters downgradient and at the property boundary, where the water conceivably could be ingested by a member of the general public, would cause a lifetime cancer risk of less than $1x10^{-10}$ (i.e., the chance of getting cancer would be less than one in ten billion if the water was ingested over a 70-year lifetime). Only arsenic and cadmium were predicted to migrate to the water table within the modeling time frame that was considered (200 years). EPA predicted that it would take chromium and molybdenum roughly 470 years to migrate from the slag pile down to the water table, while lead released from the slag pile was predicted to be bound up in the unsaturated zone for over 1,000 years.

Surface Water Risks

To evaluate surface water risks, EPA modeled a 1.8 m^3/sec (65 ft^3/sec) stream located 120 meters from a 24 hectares (60-acre) slag pile, which are roughly the conditions that currently exist at the facility in White Pine, MI. Considering the annual loading of contaminants to the stream via ground-water seepage and erosion, the Agency predicted the surface water concentrations of the following constituents after they have been fully mixed in the stream's annual average flow: arsenic, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, and zinc. EPA then compared the predicted concentrations of these constituents to cancer risk levels, noncancer effect thresholds, MCLs, freshwater ambient water quality criteria (AWQCs) for chronic exposures, and the NAS recommended guidelines for livestock and irrigation waters. Note that this approach does not account for removal, via treatment, of constituents in drinking water, and is thus conservative for that pathway.

EPA's predicted concentrations of cadmium, chromium, nickel, and zinc in the stream were at least two orders of magnitude below the various criteria. The estimated concentration of mercury also did not exceed any of the criteria, although it was within a factor of 0.7 times the AWQC.[18] The estimated concentrations of arsenic, copper, lead, iron, and molybdenum exceeded at least one of the criteria. All of these constituents were predicted to migrate into the stream by erosion of fine particles from the slag pile (seepage of contaminants into ground water with subsequent discharge into the stream resulted in a negligible pollutant loading). In particular:

- The estimated concentration of arsenic in the stream would cause a lifetime cancer risk of 6×10^{-5} if ingested over 70 years. This arsenic concentration, however, is two orders of magnitude below the MCL.
- The predicted concentration of copper equaled the NAS recommended guideline for irrigation water and exceeded the AWQC by a factor of 65. Research has shown that if water with copper concentrations in excess of the NAS guideline is used continuously for irrigation, it could be toxic to plants. Exceedance of the AWQC indicates that the copper concentrations in waters near copper slag piles could be harmful to aquatic organisms.
- The estimated concentration of lead exceeded the proposed revised MCL by a factor of 1.1 and the AWQC by a factor of 1.7. This lead concentration could cause a variety of subtle biochemical and cellular effects if consumed on a long-term basis, and adversely affect the health of aquatic organisms living in affected waters.
- The estimated concentration of iron exceeded the MCL by a factor of 3.7 and the AWQC by a factor of 1.1. Concentrations of iron in excess of the MCL could cause objectionable tastes and stains. Exceedance of the AWQC indicates that the iron concentrations in waters near copper slag piles could be harmful to aquatic organisms.
- The estimated concentration of molybdenum exceeded the NAS irrigation guideline by a factor of 2.1. Although molybdenum concentrations in excess of the NAS guideline have not been shown to be toxic to plants, they can be toxic to animals that forage on plants irrigated with the water.

Of the constituents that were modeled, only mercury is recognized as having the potential to biomagnify (concentrate in the tissue of organisms higher in the food chain). However, considering the low mercury concentrations that were predicted, EPA does not expect adverse effects due to biomagnification. Cadmium, lead, and zinc (and to a lesser extent, the other constituents) may bioaccumulate in the tissue of freshwater fish that could be consumed by people. However, based on a "worst-case" exposure analysis using the predicted surface water contamination caused by copper slag, EPA does not believe that the ingestion of fish from the affected water would pose a health threat.

The Agency believes that these estimates reasonably represent the conditions that could occur at the facility in White Pine, MI if the on-site slag pile was not equipped with stormwater run-off controls. Except for the contaminant concentrations in the slag and slag leachate, which were measured at the Garfield and Playas facilities, all of the site-specific conditions that were modeled are generally representative of the White Pine facility. Furthermore, as discussed above, the concentrations that were modeled are approximately equal to median concentrations measured in copper slag at all ten facilities (i.e., they are reasonably representative of the concentrations observed across the industry). However, because the slag pile is equipped with run-off controls, the Agency believes the above estimates represent conservative upper bound risks at White Pine, as well as at the other nine active copper facilities. The other facilities are located in much more arid and remote areas where there is a smaller potential for contaminant releases and exposures via the surface water pathway (as described above in the analysis of release, transport, and exposure potential).

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[18] This estimated mercury concentration in the stream is considered very conservative because it is based on a non-detected mercury concentration in copper slag solids. For the purpose of this analysis, EPA assumed that mercury is present in the slag solids in a concentration that equals the full detection limit.

Air Risks

EPA modeled the release of windblown dust from the slag pile and the associated inhalation risks of a hypothetical maximum exposed individual assumed to live 90 meters away in the predominant wind direction. The distance of 90 meters was chosen because, based on an analysis of the population distribution around the ten active copper facilities, it is a typical "close" distance between copper slag piles and nearest residences. For this distance, the Agency predicted the airborne concentrations and inhalation risks of arsenic, chromium, and nickel, which are all carcinogens through the inhalation pathway (chromium was conservatively assumed to exist in the carcinogenic hexavalent form). In general, the Agency's approach for modeling releases was very conservative because it assumed that there is an "unlimited reservoir" of fine particles that can be blown into the air from copper slag piles. As discussed previously, copper slag actually has limited wind erosion potential because the vast majority of slag on the piles consists of large particles that are not suspendable or transportable at typical wind speeds.

Even with this conservative approach, risks caused by the inhalation of dust from the hypothetical copper slag pile were predicted to be low. At the hypothetical residence assumed to be 90 meters from the slag pile, the total lifetime cancer risk caused by the inhalation of arsenic, chromium, and nickel was estimated to be 1×10^{-6}. Considering the conservative modeling approach that was used, EPA believes that this estimate represents a reasonable upper bound of the inhalation risks caused by copper slag piles at the ten active facilities.

6.3.2 Risks Associated With Copper Slag Tailings

Any potential danger to human health and the environment from copper slag tailings depends on the presence of toxic constituents in the tailings that may pose a risk and the potential for exposure to these constituents based on facility setting and management practices. These factors are discussed separately below.

Constituents of Concern

Using the same process outlined above for copper slag, EPA identified chemical constituents in the copper slag tailings that may pose a risk by collecting data on the composition of slag tailings, and evaluating the intrinsic hazard of the slag tailings' chemical constituents.

Data on Copper Slag Tailings Composition

EPA's characterization of copper slag tailings and its leachate is based on data from two sources: (1) a 1989 sampling and analysis effort by OSW; and (2) industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, radium-226, uranium-238, and sulfate in total solids and/or leach test analyses. Two of the three facilities that generate the slag are represented by these data: Kennecott in Garfield, Utah, and Magma Copper Company in San Manuel, Arizona.

Concentrations in total samples of the slag tailings are generally consistent for most constituents across all data sources and facilities. The exceptions are for lead -- concentrations of lead in tailings samples from the two facilities differed by over three orders of magnitude; and molybdenum -- the concentration of molybdenum in slag tailings from the Garfield facility was three orders of magnitude higher than the concentration measured in tailings from the San Manuel facility. Concentrations from leach test analyses of the slag tailings are consistent across the data sources, types of leach tests (i.e., EP, SPLP, and TCLP), and facilities.

Identified Constituents of Concern

Exhibits 6-7 and 6-8 present the results of the comparisons for copper slag tailings total analyses and leach test analyses, respectively, to the risk screening criteria. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

From the 21 constituents analyzed in copper slag tailings solids, only arsenic, chromium, and lead concentrations exceed the screening criteria (see Exhibit 6-7). Arsenic and chromium concentrations in the slag tailings exceed the inhalation pathway screening criteria. This indicates that if the slag tailings are blown into the air as dust and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter, these two constituents may be present in concentrations that could cause a cancer risk of greater than 1 x 10^{-5}. Arsenic and lead concentrations in the tailings solids exceed the incidental ingestion screening criteria. This means that, if the tailings are incidentally ingested on a routine basis (e.g., if children playing on abandoned waste piles inadvertently ingest the tailings), arsenic would pose a cancer risk of 1 x 10^{-5} or more, while lead could cause adverse noncancer effects. All three constituents were detected in more than 90 percent of the samples analyzed at concentrations exceeding the screening criteria. All three constituents were also detected in concentrations that exceed the screening criteria by a factor of ten or more.

Based on a comparison of leach test concentrations of 22 constituents to the surface and ground-water pathway screening criteria (see Exhibit 6-8), only 7 constituents (copper, molybdenum, arsenic, lead, silver, nickel, and mercury) were detected at levels above the screening criteria. All of these constituents are metals or other inorganics that do not degrade in the environment. Arsenic exceeded the screening criteria in 12 out of 13 samples, and the highest measured arsenic concentration exceeds the drinking water criterion by a factor of 900. Nickel and mercury, on the other hand, were found to exceed the screening criteria in only 20 to 30 percent of the samples analyzed, and only by a factor of 2 or less. Despite these exceedances of the screening criteria, no constituents were detected in the leachate in concentrations that exceed the EP toxicity regulatory levels.

These exceedances indicate the potential for the following types of impacts under the following conditions:

- Concentrations of arsenic and copper in the slag tailings leachate are high enough that, if the leachate is released to ground water and diluted only by a factor of 10 during migration to a drinking water well, long-term ingestion of the water could cause adverse health effects.
- Concentrations of copper, arsenic, silver, nickel, and mercury in slag tailings leachate could present a threat to aquatic ecological receptors if it migrates (with a 100-fold dilution) to surface waters.
- If the leachate is released and diluted by a factor of ten or less, copper, molybdenum, arsenic, and lead concentrations could exceed drinking water maximum contaminant levels or guidelines for irrigation water.

These exceedances of the risk screening criteria, by themselves, do not prove that copper slag tailings pose a significant risk. The criteria exceedances outlined above only indicate that the tailings may present a hazard under a set of very conservative, hypothetical exposure conditions. To determine the risks associated with copper slag tailings, therefore, EPA proceeded to the next step of the risk analysis to examine the actual release, transport, and exposure conditions that exist at the facilities that actively generate and manage the tailings.

Release, Transport, and Exposure Potential

The following analysis considers the baseline hazards of copper slag tailings at the three plants of interest in 1988. For this analysis, EPA did not consider the hazards of off-site disposal or use of the tailings because the tailings currently are never disposed of or used off-site (although slag tailings have been used off-site for construction purposes in the past and conceivably could be used again in the future). Alternative

Exhibit 6-7
Potential Constituents of Concern in Copper Slag Tailings Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Arsenic	26 / 27	Ingestion* Inhalation*	26 / 27 26 / 27	1 / 2 1 / 2
Chromium	8 / 9	Inhalation*	8 / 9	1 / 2
Lead	27 / 27	Ingestion	25 / 27	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

Exhibit 6-8
Potential Constituents of Concern in Copper Slag Tailings Leachate(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Copper	3 / 3	Human Health Resource Damage Aquatic Ecological	2 / 3 2 / 3 3 / 3	2 / 2 2 / 2 2 / 2
Molybdenum	2 / 2	Resource Damage	2 / 2	2 / 2
Arsenic(c)	12 / 13	Human Health* Resource Damage Aquatic Ecological	12 / 13 9 / 13 7 / 13	2 / 2 1 / 2 1 / 2
Lead(c)	9 / 13	Resource Damage	9 / 13	2 / 2
Silver(c)	9 / 13	Aquatic Ecological	6 / 13	1 / 2
Nickel(c)	2 / 11	Aquatic Ecological	2 / 11	1 / 2
Mercury	1 / 3	Aquatic Ecological	1 / 3	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP leach test results.

practices for managing the tailings are discussed in Section 6.5. In addition, the following analysis does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future, because of a lack of information on possible future conditions.

Ground-Water Release, Transport, and Exposure Potential

As discussed in the preceding section, EPA and industry test data show that several constituents are capable of leaching from copper slag tailings in concentrations that exceed the risk screening criteria. Considering only those constituents that are expected to be mobile in ground water (given the existing tailings management practices and neutral pH of the leachate), slag tailings contaminants that pose the primary potential threat are arsenic, mercury, and molybdenum. The ground-water release and transport potential of copper slag tailings at the three facilities depends on site-specific management practices and environmental settings.

The single tailings pond at the White Pine facility is underlain by recompacted local clay and in-situ clay that helps limit leachate from the pond reaching the underlying aquifer. Nevertheless, the large quantity of standing liquid in the pond (the pond is 16 meters deep and covers 972 hectares (2,400 acres)) produces a considerable hydraulic head that could drive leachate from the tailings into the subsurface. Furthermore, any constituents released from the units could be transported readily through the 6 to 12 meters of fractured rock that lies between the pond and the stratum identified as the uppermost aquifer. Any ground-water contamination from the unit, especially arsenic contamination, could restrict the potential future uses of this aquifer. However, the potential for current human health impacts from ground-water contamination is expected to be minimal because, to the best of EPA's knowledge, there are currently no drinking water wells within a mile downgradient of the facility, and the aquifer is not being used as a municipal drinking water supply.

At the Garfield facility, fresh slag tailings are discharged as a slurry to a tailings impoundment. This impoundment is now about 46 meters above the original grade and covers about 2,300 hectares (5,600 acres). Dried tailings are used to form a berm that creates the impoundment into which the slurried tailings are discharged. In theory, tailings contaminants could be released to ground water by seepage of the ponded water or by rain water infiltrating through dry areas of the impoundment. However, factors that limit the migration of leachate from the tailings impoundment to the uppermost useable aquifer include: the precipitation (40 cm/year) and net recharge in the area (0.7 cm/year) are relatively low; and the aquifer is very deep (i.e., 90 meters) and is primarily overlain by a zone of impermeable clay. In addition, the potential for current human health impacts from any contamination from the tailings impoundment, should it occur, appears minimal because there are currently no drinking water wells within a mile downgradient of the facility to the best of EPA's knowledge. The shallow ground water at the site is saline (and generally unuseable) because it is hydraulically connected with the Great Salt Lake.

The five tailings ponds at the San Manuel plant are not lined and have no leachate collection systems or other controls to limit releases to ground water. These ponds, which are 40 to 60 meters deep and cover anywhere from 140 to 330 hectares (350 to 820 acres), may have quantities of supernatant liquids that potentially provide sufficient hydraulic head to drive contaminants to the underlying aquifer. However, the uppermost useable aquifer beneath this facility is located 140 meters beneath the tailings ponds and is separated by an intervening alluvial aquifer. Ground-water monitoring data indicate that contamination of the useable aquifer has occurred at this site. Sulfate, which is present in the tailings but was not measured in the tailings leachate, has been detected downgradient of the facility at levels exceeding drinking water standards. (The Agency's review of State and EPA regional files did not provide evidence that this ground-water contamination is attributable to slag tailings management.) Any contaminant migration from the slag tailings into the uppermost useable aquifer has a high potential for posing current human health risks and restricting potential future uses of the ground water because approximately 4,000 people rely on the aquifer for drinking water from a municipal well located only 150 meters downgradient from the facility.

Surface Water Release, Transport, and Exposure Potential

Constituents of concern in copper slag tailings theoretically could enter surface waters by migration of slag tailings leachate through ground water that discharges to surface water, or by direct overland (stormwater) run-off of dissolved or suspended slag tailings constituents. As discussed above, the following constituents that are mobile in ground water leach from the slag tailings at levels that potentially could pose human health or aquatic ecological threats or damage surface water resources: molybdenum, arsenic, and mercury. The other constituents in slag tailings could potentially migrate to surface water via overland erosion.

At the White Pine facility, excess water in the tailings pond, which could contain entrained tailings solids, is discharged directly to a river located 120 meters away via a NPDES-permitted outfall. It is also possible for the tailings contaminants to migrate to the river via ground-water seepage. Water quality monitoring in the river has identified cadmium, selenium, copper, and total dissolved solids concentrations in excess of drinking water standards, as well as cadmium, copper, lead, selenium, and zinc levels that exceed the ambient water quality criteria. The slag tailings could be a contributor to this contamination because, based on EPA and industry test data, copper and lead are readily leachable from the tailings. The river near this facility has a relatively low dilution capacity (flow of 42 mgd), and potential drinking water exposures could occur at a water supply intake 5 km downstream (it appears that 25 people rely on this intake). Therefore, if not sufficiently diluted, any contaminants entering the river could potentially harm aquatic life, restrict the future uses of the river as a resource, and pose health risks to existing populations.

At the Garfield facility, the potential for routine overland releases to the Great Salt Lake are limited by the distance to the lake (300 meters), stormwater run-on/run-off controls, the gentle topographic slope (0 to 2 percent), and the relatively low amount of precipitation in the area (40 cm/yr). Although unlikely, episodic overland releases could occur in the event of a flood (the facility is located in a 100-year floodplain). Release of contaminants to surface water is also possible by infiltration of contaminants to the surficial aquifer that is hydraulically connected with the lake. Releases to Great Salt Lake have a low potential for adversely affecting human health because the lake is not used for drinking water.

Contaminants from slag tailings ponds at the San Manuel plant possibly could migrate to the San Pedro River located 790 meters away via seepage to the alluvial aquifer that may discharge to the river. As discussed in the preceding section on ground water, seepage to the surficial aquifer is possible due to the leachability of the waste, lack of ground-water controls, and standing liquids in the ponds. Overland run-off of the tailings could only occur in the event of a major storm causing overflow of tailings from the ponds. Such overflow is unlikely, however, because of the plant's stormwater run-on/run-off controls, low precipitation (50 cm/year) available for run-off, and moderate topographic slope (2 to 6%). The San Pedro River near this facility has a low flow rate (0.08 mgd), which provides only a limited dilution capacity. The river water is used for livestock watering approximately 1.2 km downstream of the facility, but currently, there are no other consumptive uses within 24 km downstream. If not sufficiently diluted, contaminants reaching the river could pose a risk to aquatic organisms and restrict potential uses of the river.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern in copper slag tailings are nonvolatile, the contaminants can be released to air only in the form of dust particles. As presented above, only arsenic and chromium are present in the slag tailings in concentrations that could pose human health risks through inhalation of respirable particles of slag tailings.

In general, particles that are $\leq$ 100 micrometer (μm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 μm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 μm in diameter are respirable. The slag tailings consist mainly of particles larger than 100 μm in diameter, and therefore, the majority of the slag tailings should not be suspendable, transportable, or respirable. The quantity of tailings disposed and the areal extent of the disposal areas, however, is such that wind transport of fine tailings material does occur if the tailings dry out.

The potential for dust to be blown into the air from the tailings impoundment at the Garfield facility is limited because the facility suppresses dust by periodically moving the location of the discharge of the tailings slurry to keep the surface of the entire impoundment wet. Nevertheless, dusting is possible because dried tailings are piled up and exposed to the wind around the perimeter of the impoundment and the entire impoundment may not always remain wet. In addition, the facility is located in an arid area where there is relatively infrequent rainfall (there are only 89 rainy days/year) and significant evaporation, which is conducive to dusting. In at least one instance, due to a facility shutdown, a large part of the tailings pile surface became dry and tailings dust was released to air whenever the wind speeds exceeded 20 mph. Ambient air quality monitoring at the facility indicated that the National Ambient Air Quality Standards (24-hour average concentration) for respirable particulate matter had been exceeded. Such airborne releases at this facility could lead to potential exposures at the closest residence, approximately 20 meters from the facility, as well as exposures to the 10,000 people that live within 1.6 km of the facility.

At the White Pine and San Manuel facilities, the slag tailings are currently submerged in the ponds, and there are no significant areas of dry tailings from which dust could be blown into the air. The San Manuel facility, however, is located in a very arid area in which significant evaporation from the tailings ponds is likely after the ponds are closed. This could allow the surface of the tailings to become dry after closure, allowing a small fraction of the tailings (i.e., those particles that are smaller than 100 μm) to be blown in the air as dust.

Proximity to Sensitive Environments

As discussed in the preceding section on copper slag, the White Pine facility is located in a fault zone, which creates the potential for damage to slag tailings containment systems in the unlikely event of an earthquake. The facility is also located in a National Forest; any contamination originating from the White Pine facility, therefore, could endanger the habitats and resources provided by the forest. The Garfield facility is located in a 100-year floodplain, which creates the potential for large episodic releases of tailings due to floods, and in a wetland. Any contamination originating from the Garfield facility could adversely affect the habitats and special functions provided by the wetland. The San Manuel facility is not located in or within one mile of an environment that is particularly vulnerable to contamination or has a high resource value.

Risk Modeling

Based upon the evaluation of intrinsic hazard, the descriptive analysis of factors that influence risk, the risk modeling results for other mineral processing wastes examined in this report, and upon a comprehensive review of information on documented damage cases (presented in the next section), EPA has concluded that the potential for slag tailings to impose significant risk to human health or the environment if managed according to current practice is generally low. Therefore, the Agency has not conducted a quantitative risk modeling exercise for this waste.

6.3.3 Risks Associated With Calcium Sulfate Sludge

This section discusses the constituents in calcium sulfate sludge that are potentially of concern, and the potential for exposure to these constituents based on facility setting and management practices.

Constituents of Concern

EPA identified chemical constituents in the calcium sulfate sludge that may pose a risk using the same process outlined above for copper slag.

Data on Calcium Sulfate Sludge Composition

EPA's characterization of calcium sulfate sludge and its leachate is based on data from two sources: (1) OSW's 1989 sampling and analysis effort; and (2) industry responses to a §3007 request in 1989. These data provide information on the concentrations of 20 metals, ammonia, and nitrate in total and leach test analyses. Both facilities that currently generate the sludge are represented by these data: Asarco in Hayden, Arizona, and Kennecott in Garfield, Utah.

Concentrations in total analyses of the calcium sulfate sludge are consistent for most constituents across all data sources and facilities. Silver concentrations in calcium sulfate sludge at the Garfield facility (OSW data), however, are more than three orders of magnitude lower than silver concentrations in sludge at the Hayden facility (industry data). Concentrations from leach test analyses of the calcium sulfate sludge generally are also consistent across the data sources, types of leach tests (i.e., EP, SPLP, and TCLP), and facilities. Copper and mercury concentrations in leachate from the sludge as determined by EP leach test analyses, however, are more than three orders of magnitude higher than the SPLP leach test concentrations.

Identified Constituents of Concern

Exhibits 6-9 and 6-10 present the results of the comparisons for calcium sulfate sludge total analyses and leach test analyses, respectively, to the screening criteria. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Exhibit 6-9
Potential Constituents of Concern in Copper $CaSO_4$ Sludge Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Arsenic	7 / 7	Ingestion* Inhalation*	7 / 7 7 / 7	2 / 2 2 / 2
Lead	9 / 9	Ingestion	7 / 9	3 / 3
Cadmium	7 / 9	Inhalation* Ingestion	6 / 9 6 / 9	2 / 3 2 / 3
Antimony	5 / 7	Ingestion	5 / 7	1 / 2
Silver	5 / 6	Ingestion	3 / 6	1 / 2
Copper	9 / 9	Ingestion	4 / 9	1 / 3

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

Exhibit 6-10

Potential Constituents of Concern in Copper $CaSO_4$ Sludge Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Arsenic	8 / 8	Human Health Resource Damage Aquatic Ecological	8 / 8 8 / 8 8 / 8	2 / 2 2 / 2 2 / 2
Selenium	7 / 8	Human Health Resource Damage Aquatic Ecological	7 / 8 7 / 8 7 / 8	1 / 2 1 / 2 1 / 2
Lead	8 / 8	Human Health Resource Damage Aquatic Ecological	8 / 8 8 / 8 8 / 8	2 / 2 2 / 2 2 / 2
Cadmium	8 / 8	Human Health Resource Damage Aquatic Ecological	7 / 8 7 / 8 7 / 8	2 / 2 2 / 2 2 / 2
Copper	8 / 8	Human Health Resource Damage Aquatic Ecological	7 / 8 7 / 8 7 / 8	2 / 2 2 / 2 2 / 2
Mercury	8 / 8	Human Health Resource Damage Aquatic Ecological	4 / 8 5 / 8 6 / 8	1 / 2 1 / 2 1 / 2
Nickel	1 / 2	Human Health Resource Damage Aquatic Ecological	1 / 2 1 / 2 1 / 2	1 / 2 1 / 2 1 / 2
Silver	6 / 8	Resource Damage Aquatic Ecological	5 / 8 6 / 8	1 / 2 1 / 2
Zinc	2 / 2	Human Health Resource Damage Aquatic Ecological	1 / 2 1 / 2 2 / 2	1 / 2 1 / 2 2 / 2
Antimony	1 / 2	Human Health	1 / 2	1 / 2
Aluminum	2 / 2	Aquatic Ecological	2 / 2	2 / 2
Manganese	2 / 2	Resource Damage	1 / 2	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

Of the 22 constituents analyzed in total analyses of copper calcium sulfate sludge, only 6 (arsenic, lead, cadmium, antimony, silver, and copper) are present in concentrations that exceed the conservative screening criteria. Among these six constituents, arsenic, lead, cadmium, and antimony present the greatest potential concern because they were detected in most of the samples analyzed (75 to 100 percent), and their concentrations in most analyses (approximately 66 to 100 percent) exceed the screening criteria. Arsenic, lead, and cadmium concentrations also exceed the criteria by the widest margins, ranging from 20 to 25,000 times the criteria.

- Arsenic, lead, cadmium, antimony, silver, and copper concentrations could cause adverse health effects if a small quantity of the sludge or soil contaminated with it is incidentally ingested on a routine basis (e.g., if children playing on abandoned sludge disposal areas inadvertently ingest some of the sludge solids).
- If dust from the sludge is blown into the air in a concentration that equals the National Ambient Air Quality Standard for particulate matter, arsenic and cadmium concentrations could pose a cancer risk exceeding 1×10^{-5} if inhaled by nearby individuals. However, as discussed in more detail in the next section, such large releases and exposures to windblown dust are considered very unlikely given the surface crust that forms on the dried sludge.

Based on a comparison of EP leach test concentrations of 20 constituents to surface and ground-water pathway screening criteria (see Exhibit 6-10), 12 constituents (i.e., arsenic, selenium, lead, cadmium, copper, mercury, nickel, silver, zinc, antimony, aluminum, and manganese) were detected at levels above the criteria. Arsenic, selenium, and lead were detected in most (if not all) of the samples analyzed in concentrations that exceed all three screening criteria (i.e., for human health, resource damage, and aquatic ecological threats). All but aluminum, antimony, and zinc exceed the criteria by a factor of 10 or more; maximum arsenic, copper, mercury, and selenium concentrations exceed one of the criteria by more than a factor of 100. Arsenic exceeds the screening criteria by the widest margin, up to a factor of 350,000. Arsenic, selenium, and cadmium were also measured in EP leachate in concentrations above the EP toxicity regulatory levels. All of these constituents that exceed the screening criteria are persistent in the environment (i.e., they do not degrade).

These exceedances have the following implications:

- If sludge leachate is released to ground water and diluted by a factor of 10 or less during migration to a drinking water well, concentrations of arsenic, selenium, lead, cadmium, copper, mercury, nickel, antimony, and zinc in the ground water could cause adverse health effects if ingested.
- Arsenic, selenium, lead, cadmium, copper, mercury, nickel, silver, zinc, and aluminum in the calcium sulfate sludge leachate could present a threat to aquatic organisms if it migrates (with a 100-fold dilution) to surface waters.
- If the leachate is released to ground water and diluted by a factor of 10 or less, arsenic, selenium, lead, cadmium, copper, mercury, nickel, silver, zinc, and manganese concentrations could exceed drinking water maximum contaminant levels or irrigation guidelines.

Concentrations above the screening criteria do not prove that the sludge poses a significant hazard, but rather indicate that the sludge could pose risks under a set of very conservative, hypothetical exposure conditions. To examine the potential for the sludge to pose hazards in greater detail, EPA analyzed the actual release, transport, and exposure conditions that exist at the two facilities that actively generate and manage the sludge.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of the sludge as it was generated and managed at the two copper plants of concern in 1988. It does not consider the hazards associated with off-site disposal or use because the sludge is managed only on-site and is not likely to be disposed or used off-site in the future. In addition, the following analysis does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of information on possible future conditions.

Ground-Water Release, Transport, and Exposure Potential

The calcium sulfate sludge is a solid material, but is generated as a thick slurry mixed with water (i.e., a slurry with a relatively high solids fraction). After being discharged to surface impoundments, the sludge solids settle out and, in the arid settings of Garfield, UT and Hayden, AZ, the supernatant liquid is generally lost to evaporation. EPA and industry test data show that 12 constituents are capable of leaching from calcium sulfate sludge in concentrations above the risk screening criteria. Considering only those sludge constituents that are expected to be mobile in ground water if released, the contaminants that pose the primary potential human health and ground-water resource damage threat are arsenic, selenium, cadmium, and mercury.

The two surface impoundments used to manage the sludge at the Garfield facility hold from 25 to 34 million gallons of the waste sludge. The surface impoundments are underlain by in-situ clay, and the water table is roughly 8 meters deep. The uppermost useable aquifer is approximately 90 meters beneath the base of the impoundments. Significant migration of sludge contaminants into ground water at this site appears unlikely because of the very arid setting -- the liquid that is discharged to the impoundment along with the sludge is expected to quickly evaporate and little precipitation and recharge is available to carry contaminants into the subsurface. Even if releases from the calcium sulfate sludge at this facility did occur, the potential for current adverse human health impacts appears low because, to the best of EPA's knowledge, there are no downgradient public or private wells within 1.6 km.

At the Hayden facility, the impoundment used to manage the sludge is equipped with a synthetic (asphalt/rubber) liner. In the event of liner failure, seepage could migrate to shallow ground water (located 6 meters beneath the land surface) because the subsurface material is composed mainly of permeable sand (80 percent) with little clay (10 percent). However, the current potential for people to be exposed to such contamination, if it were to occur, is low because facility personnel report that the aquifer under the site is not used for drinking water or any other purpose.

Surface Water Release, Transport, and Exposure Potential

Constituents of potential concern in calcium sulfate sludge, in theory, could enter surface waters by migration of sludge leachate through ground water that discharges to surface water, or by direct overland (stormwater) run-off of dissolved or suspended sludge contaminants. As discussed above, the following constituents that are expected to be mobile in ground water leach from the calcium sulfate sludge at levels above the risk screening criteria: arsenic, selenium, cadmium, and mercury. Other sludge constituents potentially could migrate to surface waters via stormwater runoff.

The potential for routine overland run-off of the sludge contaminants to surface waters due to overflow from the sludge management ponds at both facilities is limited by stormwater run-on/run-off controls at the units, low to moderate precipitation (40 to 50 cm/yr), and gentle topographic slopes at the sites (up to 2 percent). Other site-specific factors include:

- The sludge impoundments at the Garfield facility are located approximately 3,300 meters from the Great Salt Lake. Given this great distance, it is unlikely that contaminants could enter the lake in potentially harmful concentrations via seepage to ground water. Furthermore, any releases to surface water at this facility have a low potential for adversely affecting human health because the Great Salt Lake is not used for drinking water.
- At the Hayden facility, releases to the Gila River located 80 meters away could occur due to seepage through ground water. There is a potential for seepage from the impoundment to ground water in the event of a liner failure, as discussed in the section

above. Contamination of the river could threaten aquatic life in the river, and restrict its potential use. Risks to current human populations via surface water contamination are not expected, however, because there are no known consumptive uses of the river within 24 km downgradient of the facility.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern in the calcium sulfate sludge are nonvolatile, the contaminants can be released to air only in the form of windblown dust particles. As presented above, only arsenic and cadmium are present in the sludge in concentrations that exceed the risk screening criteria for inhalation. Although the sludge consists of very fine particles (0.02 micrometers or less in diameter), which are highly susceptible to wind erosion, the surface of the sludge dries to form a surface crust that is expected to limit dusting to a large extent.

At the Garfield facility, one of the ponds is allowed to dry while the other pond receives sludge discharges in the form of a slurry. The dried sludge is dredged, stabilized, and disposed in an on-site landfill. During the period that the sludge is dried and exposed to the wind, but before it is dredged and stabilized, wind erosion is possible although limited by the surface crust that forms on the dried sludge. Once stabilized and buried, windblown emissions should not be a problem. If there is any dust blown into the air from dried sludge standing in the impoundment, there is a resident within 100 meters and a total of 10,000 people living within 1.6 km that could be exposed.

At the Hayden facility, the sludge is accumulated at the bottom of an impoundment in a wet or moist form. In this form, airborne releases of dust from the sludge should be negligible. However, the facility is located in a very arid area (Arizona) and the impoundments dry out between wastewater discharges. Dusting from such a dried, inactive impoundment is possible but, again, the surface crust that forms on the sludge after it is dried should help to keep the dust down. If any airborne releases were to occur, the nearest resident (located 90 meters away) as well as the 2,200 people living within 1.6 km could be exposed through the inhalation pathway.

Proximity to Sensitive Environments

As discussed above, the Garfield facility is in a 100-year floodplain, which creates the potential for large episodic releases of the sludge due to flood events. The sludge impoundments at the facility, however, are roughly 3,300 meters from the Great Salt Lake and therefore are unlikely to be affected by floods. The Garfield facility is also in a wetland, which are highly valued because they provide abundant habitat, purify natural waters, and provide flood and storm damage protection, as well as a number of other functions. The Hayden facility is not located in or within a mile of an environment that is vulnerable to contamination or has a high resource value.

Risk Modeling

Although the potential for release and exposure to calcium sulfate sludge contaminants appears to be generally low based on facility settings and management practices, the intrinsic hazard of the sludge composition compelled EPA to rank the sludge as having a relatively high potential to cause human health and environmental risks (compared to other mineral processing wastes studied in this report). Therefore, EPA used the model "Multimedia Soils" (MMSOILS) to estimate the ground-water and surface water risks caused by the management of calcium sulfate sludge at the facilities in Hayden, AZ and Garfield, UT. EPA did not model the risks caused by windblown dust because, as discussed above, the surface of the sludge dries to form a crust that should keep windblown dust to a minimum.

Ground-Water Risks

Using site-specific data with respect to contaminant concentrations, sludge quantities, existing management practices, and hydrogeologic characteristics, EPA modeled potential releases to ground water from the calcium sulfate sludge impoundments at the Hayden and Garfield facilities. The Agency used median contaminant concentration as inputs to the model in order to obtain a "best estimate" of the most likely risks. EPA considered in this analysis the potential releases of arsenic, cadmium, selenium, and mercury, which are the primary constituents of concern through the ground-water pathway based on the preceding analysis of the sludge leachate.

The Agency's ground-water modeling results indicate that all four of these contaminants are likely to remain bound up in the unsaturated zone well beyond the modeling time frame that was considered (200 years). Even though the sludge is generated as a slurry and discharged to impoundments along with liquids, the liquids quickly evaporate in the extremely arid settings of these facilities. After evaporation of the slurry water, the only force available to drive contaminants from the dried sludge to the subsurface is the infiltration of precipitation, which occurs at a very slow rate in these areas of Arizona and Utah. Combining this factor along with the depth to ground water at these sites and the tendency of each contaminant to bind to soil, the Agency predicted that it would take the contaminants at least 350 years to migrate to the water table. Therefore, the predicted risks associated with the release of these contaminants to the subsurface are effectively zero within the 200-year modeling horizon.

Surface Water Risks

To evaluate surface water risks, EPA modeled potential releases and impacts at the facility in Hayden, AZ, which presents by far the greatest surface water threat of the two facilities that generate the sludge (the Hayden facility is located only 80 meters from the moderately sized Gila River, while the impoundments at the Garfield facility are located roughly 3,300 meters from the Great Salt Lake). EPA considered in this analysis the annual loading of contaminants to the Gila River via ground-water seepage and erosion of fine particles from the calcium sulfate sludge impoundment, conservatively assuming that the impoundment is filled with sludge and not covered or equipped with stormwater run-off controls -- even though the impoundment is actually equipped with run-off controls. The Agency predicted the surface water concentrations of 12 constituents after they have been fully mixed in the river's flow: aluminum, antimony, arsenic, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc. For each constituent, the Agency compared the predicted concentrations to EPA-approved benchmarks for human health protection, drinking water maximum contaminant levels (MCLs), freshwater ambient water quality criteria (AWQCs) for chronic exposures, and guidelines for irrigation and livestock waters recommended by the National Academy of Sciences.

For all but two constituents, the predicted concentrations in the Gila River were at least one order of magnitude below the various criteria, and most constituent concentrations were more than two orders of magnitude below the criteria. The exceptions were arsenic, the only carcinogen of potential concern, and silver. The predicted concentration of arsenic in the river, if ingested over a lifetime, poses a cancer risk of $2x10^{-4}$ (i.e., the chance of getting cancer would be 2 in 10,000 over a 70-year lifetime). However, this arsenic concentration is approximately an order of magnitude below the MCL. Furthermore, to the best of EPA's knowledge, the Gila River is not currently used for drinking water within 24 km of the Hayden facility, although it conceivably could be used in the future.

The predicted concentration of silver in the Gila River exceeded the AWQC designed to protect aquatic organisms by a factor of almost three. Chronic exposures to this silver concentration could adversely affect any organisms living in the Gila River.

Of the constituents that were modeled, only selenium is recognized as having the potential to biomagnify (concentrate in the tissues of organisms higher in the food chain). Although EPA predicted surface water concentrations of selenium that were more than two orders of magnitude below the AWQC, there is a potential for selenium to biomagnify and cause adverse effects to wildlife at higher trophic levels.[19] Cadmium, selenium, zinc, lead, and to a lesser extent, arsenic may bioaccumulate in the tissue of freshwater fish that may be ingested by humans. Using assumptions about fish ingestion rates,[20] the Agency estimates that long-term ingestion of fish caught from the Gila River could pose a cancer risk of 3×10^{-6}. Fish ingestion would not result in a chemical dose that exceeds a noncancer effect threshold.

EPA believes these are reasonably conservative, upper-bound estimates of the surface water risks at the Hayden Facility. As discussed above, the impoundment at this facility is actually equipped with stormwater run-off controls and, depending on the efficiency of these controls, the concentrations of contaminants in the Gila River should be lower than predicted.

6.3.4 Damage Cases

EPA reviewed State and EPA regional files in an effort to document the performance of waste management practices for slag, slag tailings, and calcium sulfate sludge from the treatment of wastewater from primary copper processing, at the 10 active facilities and at eight inactive (at least with respect to primary copper processing) facilities. The inactive facilities included: Cox Creek Refining in Baltimore, MD; ASARCO in Tacoma, Washington; ASARCO in Corpus Christi, Texas; Anaconda in Anaconda, Montana; AJO in New Cornelia, Arizona; South Wire Co. in Carrolton, Georgia; Highland Boy Smelter in Near Salt Lake, Utah; and Midvale Slag in Midvale, Utah.

The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found no documented environmental damages attributable to slag tailings or calcium sulfate sludge management. EPA did find documented environmental damages associated with copper slag at four facilities: ASARCO in Tacoma; ASARCO in El Paso; Anaconda in Anaconda; and Midvale Slag in Midvale.

ASARCO, Tacoma, Washington (Commencement Bay, Puget Sound)

ASARCO's smelter is located in the Nearshore area close to Ruston. The plant, operational from the late 1800's until March 1985, generated copper slag that has been deposited along the shoreline near the plant and has been used as fill, riprap, and ballast material in the Tideflats area of Commencement Bay. The slag has also been used to produce building insulation and commercial sandblasting material, which has been used in the Nearshore/Tideflats area.[21]

Commencement Bay is an embayment of approximately nine square miles in southern Puget Sound, Washington. The bay opens to Puget Sound to the northwest, with the city of Tacoma situated on the south and southeast shores. Residential portions of northeast Tacoma and the Browns Point section of Pierce County occupy the north shore of the bay.

From November 1983 through June 1984, the Washington Department of Ecology Water Quality Investigation Section (WQIS) conducted a remedial investigation to characterize surface run-off from 12 log storage and sorting facilities ("sort yards") in the Tideflats area and contamination of adjacent surface water and sediment in the Blair and Hylebos Waterways. These log sort yards have received ASARCO's slag as ballast material.[22,23]

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[19] The AWQC for selenium does not necessarily protect against biomagnification.

[20] For the purpose of this screening-level analysis, EPA assumed that a 70-kg individual ingests 6.5 grams of fish from the Gila River every day of the year for 70 years. This is a typical daily fish intake averaged over a year (EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989).

[21] Tetra Tech, Inc., 1985, Summary Report for Commencement Bay Nearshore/Tideflats Remedial Investigation, August, 1985.

According to the WQIS report dated February 27, 1985: "Metals concentrations were measured in run-off from twelve log sort yards on the Tacoma tideflats and in the adjacent surface waters and sediments of Blair and Hylebos Waterways. High concentrations of arsenic, zinc, copper, and lead were present in the run-off from ten yards....The combined annual metals loads (pounds/year) to Commencement Bay waterways from all twelve yards were estimated to be: arsenic, 2,500; zinc, 1,100; copper, 510; lead, 310; nickel, 66; antimony, 50; and cadmium, 2. Because it appears surface run-off accounts for only about 40 percent of the rainfall in these sort yards, there is a strong probability that contaminated groundwater may be a substantial additional source of metals flux to the waterways....Peak concentrations of arsenic, zinc, and copper in surface water and sediments in Blair and Hylebos Waterways were recorded in the vicinity of the log sort yards. EPA acute criteria for the protection of saltwater aquatic life were exceeded for zinc and copper in Blair and Hylebos surface waters adjacent to discharges from Murry Pacific yards #1 and #2 as well as the Wasser/Winters yard....The use of ASARCO slag for ballast at the log sort yards is, in all probability, the major source of elevated metals concentrations seen in log sort yard run-off, nearshore surface waters, and sediments."[24]

WQIS did a comparison of metals concentrations in ASARCO slag and WQIS data on log sort yard run-off, nearshore surface water, and sediment. The WQIS report concluded that the major source of elevated metal concentrations seen in the log sort yard run-off, and adjacent surface waters and sediment, was the ASARCO slag previously used by the yards for ballast.[25]

During 1986 and 1987 EPA conducted site inspections of four log sort yards and one wood waste landfill (B&L Landfill) in the Nearshore/Tideflats. The inspection included the installation of 23 monitoring wells, and collection of 25 soil samples and 68 ground-water samples. Soil samples taken at log sort yards indicated arsenic content ranging from 5.5 to 8.2 mg/kg, copper content ranging from 3.0 to 24 mg/kg, lead ranging from 2.7 to 10 mg/kg, and zinc ranging from 22 to 55 mg/kg. Unfiltered ground-water samples from wells installed at the log sort yards contained arsenic at levels ranging from 0.011 to 0.22 mg/L, copper ranging from 0.018 to 0.696 mg/L, lead ranging from 0.0074 to 0.300 mg/L, and zinc ranging from 0.025 to 0.865 mg/L.[26]

According to the EPA site inspection report for the Nearshore/Tideflats area, of the 19 ground-water monitoring wells installed in or around the four log sort yards, ground-water samples from 15 of the 19 wells exceeded one or more drinking water standards, maximum contaminant levels (MCLs), or freshwater and marine acute and chronic ambient water quality criteria (WQC) identified for one or more of the four contaminants of concern (arsenic, copper, lead, zinc).[27]

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[22] Norton, Dale, and Johnson, Art, 1985a, Washington Department of Ecology, Water Quality Investigation Section, Memo to Jim Krull, Re: Completion Report on Water Quality Investigation Section Project for the Commencement Bay Nearshore/Tideflats Remedial Investigation: Metals Concentrations in Water, Sediment, and Fish Tissue Samples from Hylebos Creek Drainage, August, 1983 - September 1984, January 25.

[23] Norton, Dale, and Johnson, Art, 1985b, Washington Department of Ecology, Water Quality Investigation Section, Memo to Jim Krull, Re: Completion Report on Water Quality Investigation Section Project for the Commencement Bay Nearshore/Tideflats Remedial Investigation: Assessment of Log Sort Yards as Metals Sources to Commencement Bay Waterways, November 1983 - June 1984, February 27.

[24] Ibid.

[25] Ibid.

[26] Ecology and Environment, Inc., 1987, Site Inspection Report: Commencement Bay Nearshore/Tideflats, Tacoma, Washington, Vols. I and II, November.

[27] Ibid.

Anaconda Smelter Site, Anaconda, Montana

The Anaconda facility is located at the southern end of the Deer Lodge Valley, approximately 25 miles northwest of Butte. From 1884 to 1980, ore from mines near Butte, Montana was transported and processed at various locations on the Anaconda site. In 1902, facilities were developed at the present smelter site on the south side of Deer Lodge Valley about one-half mile east of the town of Anaconda. Ore was mechanically concentrated, roasted, and smelted in reverberatory furnaces to produce copper matte and slag (as a waste product). The slag was cooled and granulated with the addition of water and the resulting slurry was transported to the waste pile through a system of flumes.[28] The facility is one of four Superfund sites in the Upper Clark Fork Basin area of southwestern Montana. Among the operable units identified for cleanup is the slag.[29]

Although the facility has not operated since 1980, ore beneficiation and processing wastes, including about 142 million cubic meters (185 million cubic yards) of tailings, about 21 million cubic meters of furnace slags, and about 190,000 cubic meters of flue dust, are contained within an area of more than 2400 hectares (6,000 acres) at the site.[30] These wastes contain elevated concentrations of heavy metals, such as copper (3,140 - 9,760 mg/kg), cadmium (4.4 - 44 mg/kg), arsenic (498 - 3,190 mg/kg), lead (364 - 4,310 mg/kg), and zinc (8,380 - 36,300 mg/kg).[31]

Anaconda's smelter slag has been used by the Montana Department of Highways for sanding roads, some of which parallel the shore of Georgetown Lake. In a November 1982 EPA report, distributed to the Technical Advisory Committee of the Clean Lakes Project in Anaconda, Montana, it was recommended that use of the smelter slag for road sanding be at least partially terminated based on the consistent occurrence of mercury in water samples that had been exposed to slag, the presence of cadmium above background levels in lake water and downstream samples, and the fact that zinc and copper are released by slag under conditions obtainable in the aquatic environment in Georgetown Lake. The report states that no danger to human health existed through contamination of the Georgetown Lake ecosystem by slag or slag leachates from road sanding operations, but that the potential existed that fish were being "negatively affected in their reproduction."[32]

A 1983 report by the U.S. Department of Health and Human Services noted that hazards from closed mining operations include potential airborne exposures from dust clouds containing heavy metals from tailings ponds or slag piles. Based on findings in this study, the report recommended that public access to the Anaconda site be terminated, that the waste slag not be used for any commercial purposes, and that further testing should be conducted.[33]

Because of the results of these findings, other agencies have reached similar conclusions. In addition to the U.S. Department of Health and Human Services, the U.S. EPA and the Montana Department of Health and Environmental Sciences have all recommended that the Anaconda smelter slag no longer be used for road sanding activities.[34,35,36]

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[28] Anaconda. 1985. Granulated Slag Pile, Draft, Stage I Remedial Investigation Report.

[29] U.S. Environmental Protection Agency, Region VIII, 1990. Letter from C. Coleman to K. McCarthy, ICF Incorporated, Re: Anaconda Smelter. May.

[30] U.S. Environmental Protection Agency and Montana Department of Health and Environmental Sciences. 1988. Clark Fork Superfund - Master Plan.

[31] Clement Associates, Inc. 1985. Letter from M.C. Lowe to M. Bishop, Region VIII EPA, Re: Response to Request by County to Use Granulated Slag on Roads.

[32] U.S. Environmental Protection Agency. 1982. Memorandum from M. Kahoe to Technical Advisory Committee Member.

[33] U.S. Department of Health and Human Services. 1983. Memorandum from Chief, Superfund Implementation Group to E. Skowronski, EPA Region 7, 8.

[34] Ibid.

[35] Camp Dresser & McKee Inc. 1985. Memorandum from J. Ericson to M. Bishop, EPA, Re: Response to County's Request to Use Granulated Slag for Winter Road and Sanding Operations.

[36] Montana Department of Health and Environmental Sciences. 1984. Letter from J.J. Drynan to G. Wicks, Director, Department of Highways, Helena, metric tons.

A 1985 Draft Stage I Remedial Investigation Report, prepared by Anaconda, noted that leachate samples from the slag pile contained cadmium at less than 0.004 to 0.03 mg/L, lead at less than 0.003 to 0.025 mg/L, and copper at 0.128 to 11.6 mg/L. The maximum leachate concentrations from these samples exceeded drinking water MCLs for cadmium (MCL = 0.01 mg/L), and copper (MCL = 1.0 mg/L). In addition, the ambient water quality criteria (AWQC) for copper (0.012 mg/L) is exceeded by almost 1,000 times, the AWQC for cadmium (0.0011 mg/L) is exceeded by almost 30 times, and the ambient water quality criteria for lead (0.01 mg/L) is exceeded by 25 times.[37] Although the use of Anaconda's slag for road sanding has been terminated, the slag material continues to be sold commercially as a sand blasting material. However, a worker at the sandblasting facility has formally complained of skin and throat irritation.[38]

Midvale Slag Site, Midvale, Utah

The Midvale Slag site is a parcel of land encompassing approximately 330 acres located immediately west of the city of Midvale, which is twelve miles south of Salt Lake City, Utah. Land use within the three mile radius of the site is primarily for agricultural, residential, and transportation purposes. The site is bounded on the west by the Jordan River, with agricultural lands immediately across the river. Residential areas border the north and east sides of the site. Approximately 33,700 individuals live within three miles of the site. EPA proposed the site for the Superfund National Priority List in 1986 (see 51 FR 21099, 21106, June 10, 1986.)

Ground water occurs beneath the site in both a shallow unconfined aquifer system, and a deep confined aquifer system. Ground water from the shallow unconfined aquifer system is used by approximately 500 residents (for domestic use that may not include drinking) and is used to irrigate approximately 24 hectares (60 acres) of agricultural land. Water from the deep confined aquifer is used as the primary source of water for many of the communities in the Salt Lake Valley. Normal annual precipitation at the site is approximately 36 cm (14 inches).

Although the first smelter was constructed at the Midvale Slag site in 1871, most of the smelting activity occurred between 1906 and 1958 when the United States Smelting, Refining, and Mining Company owned the property. Beginning in 1905, the smelter processed copper and lead concentrates from the United States Smelting, Refining, and Mining Company Mill, and from custom shippers. Remnants of the smelter activity include a large slag pile, approximately 40 hectares (100 acres) in size.

In 1958, operations at the smelter ceased, and shortly thereafter the smelter facilities were dismantled. The site was purchased in 1964 by Valley Materials Corporation (VMC), which recovers the slag material for use as road and railroad bed construction material, and as a sandblasting abrasive for industrial and commercial use.

A 1986 hydrogeochemical site characterization study, conducted for VMC, showed that contamination of the shallow (unconfined) aquifer has occurred. Dissolved arsenic, cadmium, and mercury were all detected at levels exceeding MCLs.[39] In discussing the cause of this contamination, the slag was not mentioned as a source; however, given the composition of the slag, the extent of the site covered with slag, and the proximity of the slag to other wastes, it seems likely that the slag is contributing to the contamination to some degree.[40] Recent hydrogeological studies at the site indicate that there is interconnection between the deep confined aquifer and shallow portions of the valley aquifer under the site.[41]

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[37] Anaconda. 1985. Granulated Slag Pile, Draft, Stage I Remedial Investigation Report.

[38] U.S. Environmental Protection Agency, Region VIII. Letter from C. Coleman to K. McCarthy, ICF Incorporated, Re: Anaconda Smelter. May.

[39] Earthfax Engineering, 1986. Hydrogeochemical Characterization of the Valley Chemicals Corporation Site, Midvale, Utah. Prepared for Valley Materials Corporation. August.

In 1987, EPA completed a "Final Preliminary Level I Endangerment Assessment" of the Midvale Slag site. As discussed in the report, various smelter wastes have been deposited on site, including slag, dross, and baghouse dust, and all contain high concentrations of heavy metals. According to the report, the slag contains up to 340 ppm arsenic, 45 ppm cadmium, 2,380 ppm copper, 9,410 ppm lead, 36 ppm silver, and 58,500 ppm zinc. As stated in the report: "None of the waste sources are adequately secured and releases have occurred through air and groundwater pathways. In addition, direct contact with these waste sources is very likely due to the extensive earth moving and industrial vehicle activity at the site."[42]

As stated in the report: "... current studies indicate that several metals are present in ground water, air (by indirect inference), and soil in the vicinity of the Midvale Slag site at concentrations that may endanger human health and the environment. Access to the site is currently not restricted and a commercial slag operation exists on-site, resulting in extensive earth moving and industrial vehicle activity on site. Fine grained waste source material may be inhaled, ingested, deposited as household dust, or deposited on nearby soils. Contaminants from the site also appear to be leaching into the ground-water system."[43]

In presenting a risk and impact evaluation, the report states: "Metal contamination from the Midvale Slag site presents a potential endangerment to human health and the environment due to actual and potential exposure and toxicity." All residents adjacent to the Midvale Slag site, as well as on-site workers, are potentially subjected to arsenic, cadmium, chromium, lead, and silver exposure via inhalation of contaminated dust. Consumption of crops or garden vegetables grown in contaminated soils may also increase human exposure to these contaminants.[44] The report also notes that children from ages six to 16 may play or ride bicycles on the waste piles, increasing the risk of ingestion.

The report concludes that "over two million tons of accumulated, unconsolidated slag waste, smelter waste, dross, and baghouse dust at the Midvale Slag site have caused metals contamination on-site and, probably, off-site."[45]

ASARCO, El Paso, Texas

ASARCO's El Paso Plant is located in El Paso, Texas, between Interstate Highway 10 and the Rio Grande River. ASARCO's smelting plant is used for the recovery of zinc, copper, and lead, for production of the principal products, copper anodes, lead bullion, and zinc oxide. ASARCO has operated the El Paso facility since 1883.

Waste smelter slag has historically been deposited on-site. Many of the present structures are built on old waste slag deposits. Slag from the zinc fuming furnace and copper reverb process is stored on-site and removed by a contractor, who crushes it and sells the material for railroad bedding or sandblasting abrasives. Lead slag is being stored on-site until it becomes economically viable to recycle and refine this material for zinc recovery.[46]

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[40] Earthfax Engineering, 1986. Leaching Potential of Slag and Slag-Based Airblasting Abrasives at the Valley Chemicals Corporation site, Midvale, Utah. Prepared for Valley Materials Corporation. June.

[41] Camp, Dresser, & McKee, 1990. Hydrogeologic information provided during the Sharon Steel Superfund Site Remedial Investigation and Feasibility Study on Operating Unit 1; Ground Water. U.S. Environmental Protection Agency Administrative Record on the Sharon Steel/Midvale Tailings site.

[42] EPA Region VIII. September, 1987. Preliminary Level I Endangerment Assessment, Midvale Slag Site. Document No.: 347-ES1-RT-FBBL, as a part of "Performance of Remedial Response Activities at Uncontrolled Hazardous Waste Sites.

[43] Ibid.

[44] Ibid.

[45] Ibid.

[46] Engineering Science, Inc. 1984. RCRA 3012 Site Inspection Comments.

Waste piles have been built on slag deposits of unknown permeability. In general, the waste piles have received smelting slag from the zinc, copper, and lead processes, fire assay crucibles, used kiln brick, iron scrap, and pond dredgings.[47]

Samples from stormwater run-off taken in 1981 and 1982 show that primary and secondary drinking water levels were exceeded for arsenic, cadmium, chromium, copper, lead, manganese, mercury, silver, and zinc. Samples from the southern edge of the slag deposits that were taken in July 1981, and September and December, 1982 show ranges of total concentrations of metals as follows: arsenic, 0.84 to 11.6 mg/L; cadmium, 2.05 - 12.0 mg/L; chromium, 0.04 - 0.31 mg/L; copper, 16 - 240 mg/L; lead, 28 - 220 mg/L; manganese, 2.3 - 12.0 mg/L; mercury, 0.046 - 0.160 mg/L; and zinc, 21 - 102 mg/L. Silver was detected at 1.28 mg/L. In addition, EP toxicity criteria were exceeded for lead, cadmium, and arsenic. The Texas Department of Water Resources concluded that ASARCO was in violation of Texas regulations prohibiting discharge of hazardous metals to inland waters (TDWR Permanent Rules 156.19.002).[48]

An Industrial Solid Waste Compliance Monitoring Inspection, conducted in 1985 by the Texas Department of Water Resources, noted that stormwaters from the slag landfills and from the plant, which has received much slag fill, have high levels of heavy metals and have discharged into the American Canal and the Rio Grande River.[49]

In 1986, a Solid Waste Compliance Monitoring Inspection Report was completed by the Texas Water Commission. When compared to concentrations upstream and downstream of the facility, elevated concentrations of arsenic, lead, cadmium, and copper in Rio Grande sediments near the ASARCO facility waste slag were found. For example, lead was detected at 7.0 mg/L upstream, 62 mg/L at the ASARCO facility, and 24 mg/L downstream.[50]

According to the Texas Water Commission, the primary problems at this site have evolved from surface run-off from slag piles and unlined settling ponds. In June 1987, The TWC Superfund Unit determined that improvements at the facility, e.g., lining the ponds and diverting surface run-off to a central retention area for sampling before discharge, had resulted in the company achieving compliance with the Texas Water Code.[51]

6.3.5 Findings Concerning the Hazards of Primary Copper Processing Special Wastes

Copper Slag

Copper slag constituents that pose the greatest potential threat to human health and environment include arsenic, copper, lead, molybdenum, and cadmium, although there are nine other contaminants that exceed the conservative risk screening criteria. Cadmium and lead measured in EP leach tests exceeded the EP toxicity regulatory levels in one out of roughly 70 samples. However, when analyzed using the SPLP test, neither of these constituents failed the EP toxicity criteria.

Based on an examination of the characteristics of each site and predictive modeling, copper slag appears to pose a low risk at most of the active copper facilities. Almost all of these facilities are located in areas with generally low-risk environmental and exposure characteristics (e.g., very low precipitation and net recharge, large depths to ground water, minimal use of nearby surface and ground-water resources, and great distances to potentially exposed populations). A possible exception is the facility in White Pine, MI. Using the conditions at White Pine as a conservative model, the Agency predicts low risks associated with potential releases of slag contaminants to ground water and air, including cancer risks that are below $1x10^{-6}$ and contaminant concentrations at possible exposure points that are orders of magnitude below hazard criteria. Erosion of contaminants into nearby surface waters, however, could cause greater impacts. The Agency predicts that, if not controlled, erosion from a slag pile could result in annual average surface water concentrations of lead, iron, and molybdenum that exceed MCLs or irrigation guidelines by a narrow margin (a factor of 2 or less), as well as copper concentrations that exceed the AWQC by as much as a factor of 65. Contamination of this magnitude, however, should not actually occur at the White Pine Facility because the slag dump at that site is equipped with stormwater run-on/run-off controls. Similarly, significant surface water contamination is not expected at the other sites because the nearest surface waters are farther away and have a greater assimilative capacity than the conservative conditions that were modeled.

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[47] U.S. Environmental Protection Agency, Region VI. No date. Surface Impoundments Site Inspection Report for Holding Pond and Storage Facilities Site Inspection Report.

[48] U.S. Environmental Protection Agency. August 27, 1984. Potential Hazardous Waste Site Tentative Disposition.

[49] Texas Department of Water Resources. 1985. Industrial Solid Waste Compliance Monitoring Inspection Report.

[50] Texas Water Commission. April 26, 1986. Solid Waste Compliance Monitoring Inspection Report.

[51] U.S. Environmental Protection Agency, Region VI. June 2, 1987. Record of Communication from Christy Smith, Head, TWC Superfund Unit to David Gonzalez, Re: ASARCO, Inc.

The general lack of documented cases of damage caused by copper slag at the active copper facilities confirms that the slag at these facilities often poses a low risk. The only damage case for an active site involved storm water run-off from slag piles at the El Paso facility and subsequent surface water contamination, as predicted to be possible by the Agency's modeling. The El Paso facility has since installed a run-off retention system. The other damage cases are for inactive facilities and demonstrate the potential for damage under mismanagement scenarios that generally do not represent the industry norm.

Copper Slag Tailings

Compared with the other copper wastes, copper slag tailings contain a smaller number of contaminants in generally lower concentrations. The greatest potential for hazard appears to be associated with the tailings' arsenic concentrations. Based on professional judgment and available sampling results, EPA believes that the tailings do not exhibit any of the characteristics of a hazardous waste.

Based on the Agency's review of existing management practices and release/exposure conditions, as well as the lack of documented cases of damage caused by copper slag tailings, the overall hazard associated with the tailings appears to be low. Although the tailings are generated as a slurry and co-managed with liquids that could serve as a leaching medium, the contaminant concentrations in the leachate are generally low. Furthermore, ground water at the three facilities that actively generate and manage the tailings is either very deep (and thus somewhat protected) or not used within a mile. It is possible, however, that the ground water could be used sometime in the future. Except for the White Pine facility, where there is a moderate potential for tailings contaminants to migrate into surface water, the potential for the tailings to cause significant surface water contamination appears very remote. Airborne dusting from the tailings piles can and does occasionally occur. Windblown dust from the piles should be studied further and, if needed, controlled to prevent significant inhalation exposures to arsenic and chromium.

Calcium Sulfate Sludge

Although calcium sulfate sludge contains as many as 12 contaminants that could pose a risk under worst-case exposure conditions, the constituents that pose the greatest potential threat to human health and the environment are arsenic, cadmium, lead, and selenium. Concentrations of arsenic and selenium in the sludge leachate, as measured using the EP leach test, exceeded the EP toxicity regulatory levels in seven out of seven samples, while cadmium exceeded the regulatory level in six of seven samples. However, using the SPLP test, no contaminants exceeded the EP toxicity regulatory levels.

Based on a review of existing management practices and facility settings, as well as predictive modeling results, EPA believes that the hazards associated with calcium sulfate sludge are generally low at the two facilities where it is currently generated. Both facilities that actively generate and manage the sludge are located in very arid locations (Hayden, AZ and Garfield, UT) where there is very little precipitation and recharge to ground water. Even the liquids used to slurry the sludge into the impoundments are expected to quickly evaporate, rather than seep into the ground. Considering this lack of water to carry sludge contaminants to the subsurface, along with the depths to ground water and the tendency of the sludge contaminants to bind to soil, EPA predicts that it would take more than 200 years for contaminants to migrate from the sludge into ground water. However, there does appear to be a slight potential for surface water contamination caused by sludge management practices at one of the sites. If the impoundment at Hayden is conservatively assumed to be filled with sludge and not equipped with a cover or run-off control system, the Agency predicts that erosion from the impoundment could cause arsenic and silver concentrations in the nearby Gila River that exceed health and ecological protection criteria. However, because the impoundment at Hayden is in fact equipped with run-off controls, surface water contamination of this magnitude is not actually expected. The potential for significant releases of windblown dust from the sludge appears very remote, because the surface of the sludge dries to form a crust that is resistant to wind erosion.

No cases of documented damage caused by the sludge were discovered by EPA. This finding supports the conclusion that as currently managed the sludge poses a generally low hazard.

The intrinsic hazard of the waste, however, is high. Several other primary copper facilities may generate the sludge in the future, especially if the waste remains excluded from RCRA Subtitle C regulations. As discussed above with respect to slag and slag tailings, the environmental settings of some of these other facilities is such that risks associated with calcium sulfate sludge generated at these facilities could be higher than at the two facilities where it is currently generated, assuming that the additional facilities used management practices similar to those currently in use. Similarly, off-site use or disposal could result in higher risks than those predicted for the facilities where the waste is currently generated.

6.4 Existing Federal and State Waste Management Controls

6.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations," which provide the basis for minimum requirements of NPDES permits, must be established for various classes of industrial discharges, which include a number of ore and mineral processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT and BAT requirements for primary copper smelting specify that there shall be no discharge of process wastewater pollutants to navigable waters (40 CFR 421.43 and 421.44).[52]

A number of States with primary copper smelter facilities do not have EPA-approved NPDES programs. In New Mexico, Region VI personnel have stated that existing Federal guidelines are applied for discharges from primary copper smelters. However, the Region may adopt State water quality criteria or any other standards that are more stringent than Federal guidelines as required by Sections 402 and 510 of the CWA. Similarly, the State of Arizona has no approved NPDES program; therefore, Federal requirements would be applicable. Region IX may, however, adopt State water quality standards more stringent than Federal guidelines.

Limitations on air emissions, National Emission Standard for Hazardous Air Pollutants (NESHAP), have been established by EPA under the Clean Air Act (40 CFR 61.12) for emissions of inorganic arsenic from primary copper smelter convertors. The standards require operators to meet certain design, equipment, work practice, and operational requirements in order to achieve emission reductions.

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[52] This limitation includes a provision, however, that an impoundment designed to contain the 10-year, 24-hour rainfall event may discharge that volume of process wastewater which is equivalent to the volume of precipitation that falls within the impoundment in excess of that attributable to the 10-year, 24-hour rainfall event, when such event occurs.

The Cyprus Miami Mining Corporation Copper Smelter in Claypool, Arizona is located on Federal land, in a National Forest. This facility is subject to the regulations set forth by the U.S. Forest Service. National Forest System lands are regulated by the U.S. Department of Agriculture's Forest Service. The regulations governing the use of the surface of National Forest Service lands (36 CFR 228 Subpart A) are intended to "minimize adverse environmental impacts...." The regulations require that operators file a "notice of intent to operate." If deemed necessary, the operator may be required to submit a proposed plan of operations in order to ensure minimal adverse environmental impact.

The National Environmental Policy Act (NEPA) may also be applicable to this facility. NEPA may require that an Environmental Impact Statement (EIS), which establishes the framework by which EPA and the Council on Environmental Quality may impose environmental protection requirements (40 CFR Parts 1500-1508), be prepared for any ore processing activities on Federal lands.

6.4.2 State Regulation

One or more of the three special wastes from primary copper processing (slag, slag tailings, and calcium sulfate sludge) are generated at 10 facilities located in five states, including Arizona (three facilities), Michigan (one facility), New Mexico (two facilities), Texas (three facilities), and Utah (one facility). All five of these states exempt the special primary copper processing wastes generated by the facilities from regulation as hazardous waste. Of these five states, only Michigan was not selected for detailed study for the purposes of this report (see Chapter 2 for a discussion of the methodology used for selecting study states). Copper slag is generated at facilities located in all four of the study states, while slag tailings and calcium sulfate sludge are generated at facilities located in Arizona and Utah only. Based on the location of the nine facilities in the four study states, and the waste streams that those facilities generate, the state regulation of primary copper processing wastes is of principal interest in the States of Arizona, Utah, and Texas.

The three primary copper processing facilities in Arizona generate one or more of this sector's three special wastes. Because Arizona's solid waste regulations classify mineral processing wastes as industrial solid wastes, all three waste streams are subject to these solid waste regulations. According to state officials, however, the state's emphasis in implementing its regulations has been on municipal solid waste landfills; the state has not imposed regulations specifically addressing wastes from mining or mineral processing operations. Arizona also has in place a ground-water discharge permitting program that specifically lists surface impoundments, including holding impoundments, storage settling impoundments, treatment or disposal pits, ponds, lagoons, and mine tailings piles or ponds, as discharging units that must be permitted. Arizona has focused its efforts to date, however, on permitting new facilities. The single facility generating calcium sulfate sludge, thus, does not have a ground-water discharge permit, while the other two facilities have permits for only selected mining and mineral processing waste units. Finally, Arizona regulations adopt federal new and existing source performance standards for primary copper smelting operations, including fugitive dust limitation conditions for tailings piles and ponds.

Utah is the only other state in which all three special wastes from primary copper processing are generated. A single copper processing facility in Utah generates all of these wastes. Utah excludes all of these processing wastes from both its hazardous waste and solid waste regulations. The state does have an approved NPDES program, however, and imposes discharge permit requirements on the tailings impoundment used for disposing slag tailings and other wastes at its one facility. The state also recently enacted new ground-water protection legislation, though it has not yet issued any ground-water discharge permits. Finally, Utah's air regulations specifically regulate sulfur dioxide and visible compounds air emissions at the facility, but address fugitive dust emissions only under general requirements for tailings ponds and piles.

The two facilities in New Mexico, three facilities in Texas, and one facility in Michigan generate copper slag only, though two of the Texas facilities do not generate smelter slag and recycle their converter and anode slag. New Mexico specifically excludes mineral processing wastes from its solid waste regulations. Both EPA and state effluent discharge limitations apply at both New Mexico facilities. Moreover, both facilities have discharge plans for the protection of ground water, though neither of the facilities' plans address slag disposal. Similarly, New Mexico's air regulations require permits for all sources of air contaminants and specify limitations for a variety of mineral processing operations, though copper processing is not mentioned specifically. In contrast to New Mexico, Texas addresses copper slag under its solid waste regulations. Only one of the three facilities in the state, ASARCO's El Paso facility, is subject to the requirements of these regulations and other environmental regulations, however. The state has not addressed the other two facilities because those facilities reuse their slag. Moreover, Texas has required only that the ASARCO plant notify the state of its waste management activities and provide basic waste characterization information; the state has not required a solid waste disposal permit at the facility because ASARCO disposes of its slag on property that is both within 50 miles of the facility and is controlled by the company. Texas surface and ground-water protection criteria and fugitive dust emission controls apply at the ASARCO facility only. Texas has not imposed fugitive dust controls at the ASARCO facility, but has actively implemented its water protection regulations and is currently administering an enforcement order addressing un-permitted releases to the Rio Grande River. Finally, although Michigan was not studied in detail for this report, review of the state's regulations suggest that the copper slag generated at the White Pine facility is exempt from solid waste regulations because it is reused.

In summary, all of the states with primary copper processing facilities exclude the special processing wastes generated at these facilities from their hazardous waste regulations. The states vary in the application of solid waste regulations to these wastes. Both Utah and New Mexico specifically exempt mineral processing wastes from solid waste regulation, while Michigan's regulations contain exemptions for slag that is reused or reprocessed. Although Arizona and Texas classify primary copper processing wastes as solid wastes, neither state has actively regulated the management of these wastes under such authority. In contrast, all of the states appear to address some or all of the copper processing wastes generated within their borders to some extent under state surface water discharge permitting programs, while Arizona and New Mexico have ground-water discharge permit programs and Utah recently enacted ground-water protection legislation that will require permits. Finally, although all of the states appear to have general fugitive dust emission control requirements that could apply to copper processing wastes, the extent to which those requirements are being applied is not clear.

6.5 Waste Management Alternatives and Potential Utilization

6.5.1 Waste Management Alternatives

Waste management alternatives, as discussed here, include both waste disposal alternatives (e.g., landfills and waste piles) and methods of minimizing the amount of waste generated. Waste minimization alternatives include source reduction or recycling that results in either the reduction of total volume or toxicity of the waste. Source reduction is a reduction of waste generation at the source, usually within a process, that can include treatment processes, process modifications, feedstock (raw material) substitution, housekeeping and management practices, and increases in efficiency of machinery and equipment. Source reduction includes any activity that reduces the amount of waste that exits a process. Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process.

Opportunities for waste minimization through raw materials substitutions are limited in general by the characteristics of the ores that are processed. Selection of source ores, improved beneficiation techniques, or improvements in smelting technology, however, in some cases may lead to reduced slag volumes. Other source reduction opportunities may involve process modifications that increase the efficiency of metal recovery during the smelting operation.

The following discussion describes opportunities for recycling copper smelter slag that are practiced in the U.S. and miscellaneous potential waste minimization practices for all three special wastes generated in primary copper processing.

Recycling Copper Slag

The primary purpose of recycling copper slag is to recover additional copper from the slag. There are six types of primary copper slag generated in the U.S.: converter, anode, reverberatory furnace, electric furnace, flash furnace, and continuous smelter slags. Opportunities for recycling slag exist primarily for the four types of smelter slag because most, if not all, of the converter and anode furnace slag generated at primary copper processing facilities in the U.S. already is recycled to the process -- anode furnace slag to the converter and converter slag to the smelter. There are three primary methods of recycling copper smelter slag used at U.S. facilities. The method used depends upon the type of smelting furnace at the facility.

Description

Recycling of reverberatory furnace slag involves crushing and screening, and a subsequent separation of the minerals in the slag by froth flotation in a concentrator. In this process, the copper is caused to float to the surface with the addition of chemicals called "floaters," and is removed in a foam of air bubbles. Other minerals sink to the bottom, are carried out in the slurry, and are disposed of in tailings ponds. The primary residuals from this process are wastewater (about 50 to 230 metric tons per metric ton of concentrate) and the tailings (about 25 to 50 metric tons per ton of concentrate.)

Electric furnace slag has a lower copper content than reverberatory furnace slag, making it less amenable to recycling using a concentrator. In fact, electric furnace treatment is one method of recycling slag, as discussed below.

Flash furnace and continuous (Noranda) smelter slags are relatively high in copper content. This copper may be reclaimed by electric furnace slag treatment or by slow cooling, crushing, and flotation. Coke is used in an electric furnace to reduce sulfates and metallic copper and reconstitute the copper as a sulfide. The molten copper matte may then be recycled to a converter to produce copper metal. In the flotation process, the molten slag is cooled slowly, and copper forms as either small particles of metallic copper or crystals of copper-iron sulfide. These particles are held in a matrix of primarily iron silicate. The slag is reclaimed, crushed, and sent to the concentrator. The concentrate is then returned to the smelting process.[53,54]

Current and Potential Use

Of the three U.S. facilities operating reverberatory furnaces in 1988, one has classified its production statistics as confidential. The two other facilities are the Copper Range Company in White Pine, Michigan, and the Magma Copper Company in San Manuel, Arizona. As noted in Section 6.2.3, the Copper Range facility generated and stored 165,000 metric tons of reverberatory furnace slag in 1988. The Copper Range Company's slag pile has accumulated 1,360,000 metric tons of slag, and the facility retrieved 212,000 metric tons of slag from the pile for recycling to the concentrator in 1988.[55] The Magma facility also added 309,000 metric tons of reverberatory furnace slag in an on-site slag pile in 1988, but "mined" and recycled 996,000 metric tons of reverberatory furnace slag from the pile.[56]

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[53] PEDCo Environmental, Inc., Industrial Process Profiles for Environmental Use, Chapter 29: Primary Copper Industry, EPA-600/2-80-170, Environmental Protection Technology Series, Industrial Environmental Research Laboratory, ORD, U.S. Environmental Protection Agency, July 1980, p. 49.

[54] White, Lane, "Copper Recovery from Flash Smelter Slags: Outokumpu Upgrades Sorting of Slags and Flotation of Copper," Engineering and Mining Journal, November 1983, pp. 77-81.

[55] Copper Range Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[56] Magma Copper Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

Electric furnaces were used by two facilities in 1988: the Cyprus Miami Mining Corporation in Claypool, Arizona and the Phelps Dodge Mining Company in Playas, New Mexico. The Cyprus facility generated 310,000 metric tons of electric furnace slag in 1988 and disposed 100 percent of it in a tailings pond. Cyprus did not recycle any slag in 1988.[57] The Phelps Dodge facility operated an electric furnace to process the slag from its flash furnace operations. Its electric furnace generated 336,000 metric tons of slag in 1988. All of the electric furnace slag was sent to a slag pile for disposal and no slag was recycled.[58]

Production statistics for three of the four U.S. facilities employing flash furnaces are non-confidential. The Phelps Dodge Mining Company facility in Playas, New Mexico, the Chino Mines Company (Phelps Dodge) facility in Hurley, New Mexico, and the Magma Copper Company facility in San Manuel, Arizona all operated flash furnaces in 1988. As noted above, the Phelps Dodge facility in Playas sent all of its flash furnace slag to an electric furnace for processing.[59] The Chino/Phelps Dodge facility in Hurley generated 363,000 metric tons of slag from its INCO flash furnace in 1988 and recycled none.[60] The Magma facility replaced its reverberatory furnaces with a single flash furnace in 1988. This flash furnace generated 190,000 metric tons of slag in 1988. Magma reportedly recycles all of its flash furnace slag to the ore concentrator.[61]

Finally, the Kennecott Copper Company in Garfield, Utah generated 395,000 metric tons of slag from its continuous Noranda process. This facility reported recycling all of the slag it generated to the slag concentrator.[62]

The two copper smelting facilities with confidential production statistics are ASARCO's facilities in El Paso, Texas, and Hayden, Arizona. The El Paso facility temporarily stores its slag in a slag pile and sells it to an on-site third party. The material is then used for railroad fill, ballast, and blasting abrasive.[63] The Hayden facility disposes of slag in an on-site slag pile and reprocesses a portion to recover the copper content.[64]

Most facilities operating flash furnaces or continuous smelters recycle their smelter slag to the process. Recycling of reverberatory and electric furnace slags is not as common. There may be potential for increasing the quantity of copper smelter slag that is recycled, but it is not clear that such an increase would be economically feasible or that it would substantially affect the volume or composition of the slag generated.

Factors Relevant to Regulatory Status

The specific effects of slag recycling on volume and composition of copper slag are uncertain. Recycling slags to a concentrator reduces volume and copper content of the slag, but creates slag tailings and associated wastewater. Electric furnace treatment of flash or continuous smelter slag generates a slag with a similar content as reverberatory furnace slag.[65]

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[57] Cyprus Miami Mining Corporation, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[58] Phelps Dodge Mining Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[59] Phelps Dodge Mining Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[60] Chino Mines Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[61] Magma Copper Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[62] Kennecott Copper Company, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[63] ASARCO Incorporated-El Paso Plant, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

[64] ASARCO Incorporated-Hayden Plant, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA.

Feasibility

It is technically feasible to increase slag recycling at facilities that do not currently recycle 100 percent of their smelter slag, but it is not certain that more recycling would be profitable. The primary factor influencing a facility's decision to recycle smelter slag is the concentration of copper in the slag. Slags with low copper content, such as the electric furnace slags, are likely to be disposed instead of recycled due to the increased costs associated with recycling and the minimal benefits (i.e., small quantities of copper recovered).

Miscellaneous Waste Minimization Practices

Some research has been conducted on removing secondary elements from copper slag. The methods researched are worth noting as potential waste minimization practices.

Copper and Secondary Metals Recovery from Converter Slag

Researchers in India have found that copper converter slag with a magnetite content of approximately 8 percent and a FeO/SiO_2 ratio of about 1.2 could be leached at high temperatures with dilute sulfuric acid to recover most of the copper and about 90 percent of the nickel and cobalt. Slags with a higher magnetite content (15-20 percent) and a greater FeO/SiO_2 ratio (1.3) only allowed 40-60 percent recovery of the secondary metals. Slow-cooling this slag, however, enhanced recovery of contained nickel and cobalt to 90 percent.[66]

Iron Recovery and Glass Fiber Reduction from Slag

Researchers from U.C.L.A. found that copper slag from ASARCO's Hayden, Arizona facility could be converted into glass fiber and that iron from the slag could be recovered. The researchers melted down a mixture of 90 percent copper slag and 10 percent $CaCO_3$ in a Harper globar electric heating furnace using graphite and coal powder as reductants. On remelting, the copper slag usually corrodes oxide refractories because of the iron in the slag, but the addition of coal or graphite to the batch lowered the slag's melting temperature and actually reduced the refractory corrosion. Iron was recovered from the slag by the reduction of the oxide through the ferrous state to the metallic state. Glass was then cast and glass fibers were drawn from the melt.[67]

Minimization of Slag Tailings and Calcium Sulfate Sludge

EPA did not find any information in the literature reviewed concerning minimization of copper slag tailings or calcium sulfate sludge generated by primary copper processing facilities. Copper slag tailings are generated when copper slag is recycled to the concentrator; therefore, the copper content of the tailings could potentially be reduced if a more effective method of concentration were developed. The quantity and composition of both slag tailings and calcium sulfate sludge could be altered if a feasible method of recovering metals (e.g., lead, zinc) were devised for these two special wastes.

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[65] PEDCo Environmental, Inc., op. cit., p. 68.

[66] Das, R.P, S. Anand, K. Sarveswara Rao, and P.K. Jena, 1987, "Leaching Behavior of Copper Converter Slag Obtained Under Different Cooling Conditions," Trans. Institution of Mining and Metallurgy (Section C: Mineral Process. Extr. Metallurgy), Vol. 96, September, p. C161.

[67] Chung, C.H., T. Minzuno, and J.D. Mackenzie, 1978, "Iron Recovery and Glass Fiber Production from Copper Slag," Proceedings of the Sixth Mineral Waste Utilization Symposium, Chicago, IL, May 2-3, pp. 145-147.

Disposal Alternatives

None of the primary copper processing facilities send their special wastes off-site for disposal. While it is conceivable that some, or even all, of the copper processors could do so, the cost of transporting large volumes of copper slag, slag tailings, or calcium sulfate sludge and the rising cost of commercial landfill capacity make it unlikely that copper processors would utilize off-site disposal capacity if on-site capacity is available and the regulatory environment does not change. Situations that could increase the likelihood of off-site disposal are the classification of one or more of the special wastes as hazardous wastes, a limited amount of capacity for on-site disposal, and smaller volumes of special wastes generated.

6.5.2 Utilization

Copper slags historically have been utilized in a variety of ways. Though most copper processing facilities currently recycle or dispose of their slag, there are numerous opportunities for utilization. The application that could potentially use the largest quantities of copper slag is use as a highway construction aggregate. Copper slag tailings have also been utilized for construction purposes in the past, but all facilities currently generating tailings dispose of them. The following section analyzes the potential, as identified in the literature, for use of copper slag in highway construction and various other capacities and discusses past uses of copper slag tailings.

Utilization as a Highway Construction Aggregate

Description

Copper slag has been used experimentally in bituminous wearing surfaces (asphalt) and as a seal coat aggregate in highway construction. Copper slag is a hard, dense material which is either granulated (water cooled) or air cooled. Granulated slags generally range from -8 mesh +100 mesh in diameter and are considered unsuitable for highway construction because of their resistance to compaction. Air cooled slags, which are the most usable as an aggregate, can range in size from +4 mesh to chunks that measure several inches in diameter. Copper slags, particularly air cooled slags, may require additional crushing and/or screening to achieve uniform sizes for particular applications.[68]

Current and Potential Use

In the past, copper slag has been used as an aggregate in asphalt and seal coats in Arizona and Utah, states which are among the top generators of copper slag. When used as an aggregate in asphalt, the copper slag performed well and was shown to have desirable anti-skid and wear resistant properties, but these pavements have a high cost associated with them due to the heavy weight (and associated transportation costs) of the aggregate. Therefore, the Utah Department of Highways concluded that the most economical use of copper slag is as a seal coat aggregate. One problem associated with surface mixtures incorporating copper slag is that the aggregate particles have a tendency to become dislodged by traffic, posing the possibility of damaging windshields.[69]

The Testing and Research Division of the Michigan State Highway and Transportation Commission investigated copper reverberatory slag from the White Pine smelter in Michigan for its suitability as an aggregate in highway construction. A number of evaluative tests were performed and the material was found to be suitable as aggregate for all types of highway construction with the exception of aggregate for portland cement concrete.[70]

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[68] Collins, R.J. and R.H. Miller, 1976, op.cit., pp. 111-112, 170.

[69] Ibid., pp. 114, 166, 170.

Access to Markets

It is important that a waste being used as an aggregate be located as close as possible to its market in order to keep transportation costs low. Wastes located within 50 to 100 miles of major metropolitan areas or aggregate shortage areas are considered as being near potential markets.[71] The Cyprus facility in Claypool, Arizona is located 70 miles from Phoenix, Arizona and the Magma facility located in San Manuel, Arizona is located 30 miles from Tucson, Arizona. Also, there is an aggregate shortage located in Northeast Arizona, Southeast Utah, and Northwest New Mexico in which the copper slag from the Arizona, Utah, and New Mexico facilities could be utilized. The Copper Range facility in White Pine, Michigan does not foresee an opportunity for utilization of its slag because of the distance from the facility to potential markets for the slag and high transportation costs, especially since there is no railhead located at the facility.

Feasibility

The major factor in determining the technical feasibility of using copper slag as an aggregate for highway construction is the mechanical properties of the slag. The economic feasibility of using copper slag as an aggregate will depend on the selling price of the slag and retrieval, processing, and transportation costs associated with a particular use in a particular area.

Miscellaneous Uses

Several examples of copper slag and copper slag tailings utilization are cited in the literature, but very few details are provided other than the fact that it has been utilized in some capacity. Given the limited availability of information, a brief discussion of these miscellaneous utilizations is provided below.

Other Construction Materials

Studies have indicated that copper slag has potential use as portland cement replacement in concrete. Mortars incorporating air cooled or quenched slag ground to 5000 cm^2/g exhibit compressive strengths that suggest the possibility of their use for structural concrete, but the costs associated with grinding might not justify this use.[72] Also, copper slag can be used as a source of iron in the manufacturing of portland cement,[73] (as distinct from use as aggregate in portland cement concrete).

There are a number of other uses of copper slag in construction materials. Granulated copper slag was used during the reconstruction of a portion of the New Jersey Turnpike as an embankment material.[74] Copper slag has also been used for road cindering, and as granules for roof shingles. The Copper Range Company in Michigan has used a very small portion (less than 1 percent) of its copper slag locally for driveways, as pipe bedding, and in road beds, when mixed with a sufficient quantity of road rock. Copper slag has been found to have very good drainage characteristics and would be well suited for drainfield construction.[75]

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[70] Collins, R.J. and R.H. Miller, 1977, Availability of Mining Wastes and Their Potential for Use as Highway Material - Executive Summary, FHWA-RD-78-28, prepared for Federal Highway Administration, September, p. 21.

[71] Ibid., p. 239.

[72] Douglas, Esther and Paul R. Mainwaring, 1985, "Hydration and Pozzolanic Activity of Nonferrous Slags," American Ceramic Society Bulletin, Vol. 64, No. 5, p. 706.

[73] Collins, Robert J., 1978, "Construction Industry Efforts to Utilize Mining and Metallurgical Wastes," Proceedings of the Sixth Mineral Waste Utilization Symposium, Chicago, IL, May 2-3, p. 141.

[74] Ibid.

Road or Railroad Ballast

Sized copper slag is an excellent material for use as road or railroad ballast because of its high natural angle of repose and its ability to maintain slopes. For example, copper slag from the Southwest was used in construction of a large portion of the Southern Pacific roadbed from New Orleans to San Francisco.[76]

Mineral Wool Insulation

The Copper Range Company in White Pine, Michigan shipped 38,486 metric tons of copper slag between November 1976 and December 1977 to mineral wool manufacturers. In mineral wool manufacturing, sized copper slag is mixed with other materials to adjust the overall composition of feed to the furnace. The slag mixture is melted with coke in a cupola furnace, and the molten stream from the furnace is spun into a mineral wool.[77] Copper slag was used in mineral wool production extensively in the past, but has largely been replaced as an input material by steel and iron slags due to the air pollution concerns associated with arsenic and hydrogen sulfide residuals in the copper slag.[78]

Application as an Abradant

Granulated copper slag is used as an abradant in abrasive machining. Other potential uses of copper slag grains are as grit in abrasive blasting, in abrasive tools bonded with low melting ceramic binders, in elastic polyurethane bonded abrasive tools, and in abrasive compounds. It has been discovered that heat treatment enhances the strength of copper slag grains, consequently increasing its potential use in abradants.[79]

Utilization of Copper Slag Tailings

Copper slag tailings and ore tailings may be co-generated by a concentrator or mixed for disposal if there are separate slag and ore concentrators at the facility. References in the literature to the use of copper tailings do not clearly state whether the past uses of tailings applied to only ore tailings, only slag tailings, or both. Presumably, the mechanical properties of both types of tailings will be similar and they could be used individually or in combination for each application.

Copper tailings were used in both Michigan and Utah as embankment material and in bituminous mixtures. In Michigan, an unspecified quantity was used as embankment and sub-base material for U.S. Route 41 and for other projects as an aggregate in bituminous mixes and as anti-skid material. Between 1972 and 1976, over 5 million metric tons of classified copper tailings from the Kennecott facility were used in the construction of highway embankments throughout the State. Kennecott constructed a separation facility in 1972 to classify and deposit coarser tailing products which are suitable for use in highway embankments. The largest use of the tailings was 3 million metric tons in the construction of 9.6 kilometers of embankment for

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[75] Snyder, Houston L., 1990, Director of Safety and Environmental Affairs, Copper Range Company, White Pine, Michigan, personal communication, April 9.

[76] Bingham, Edward R., 1968, "Waste Utilization in the Copper Industry," Proceedings of the First Mineral Waste Utilization Symposium, Chicago, IL, March 27-28, p. 75.

[77] Clarkson, J.F., R.H. Johnson, E. Siegal, and W.M. Vlasak, 1978, "Utilization of Smelter Slags at White Pine Copper Division," Proceedings of the Sixth Mineral Waste Utilization Symposium, Chicago, IL, May 2-3, p. 99.

[78] Brayman, Bill, Vice President, Rockwool Manufacturing Company, Leeds, Alabama, personal communication, April 11, 1990.

[79] Wozniak, K., 1988, "Cutting Property Assessment of Copper Slag," Metal Finishing, November, p. 37.

Interstate 215. Utah also used tailings as a mineral filler in bituminous mixtures, but the Department of Highways found that this application was not as successful as use in embankment construction.[80]

Conclusions

Although copper slag and slag tailings are commonly either recycled or disposed of in stacks or ponds, there does appear to be some potential for utilization of these materials, particularly in construction applications. There is no indication in the literature reviewed that there are any potential means of utilizing calcium sulfate sludge. If the special wastes were used as construction materials there might, under some circumstances, be concerns regarding potential contaminant release and subsequent environmental degradation. It is unclear whether such non-disposal management alternatives represent a net reduction in the risks posed by these materials as compared to current practices. One major obstacle to more widespread utilization of the special wastes is social acceptability. While utilization of copper slag and slag tailings is likely to be more acceptable to the public than utilization of some of the other special wastes (e.g., lead slag), some opposition to their use in construction materials or in other capacities may be expected.

6.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed under different regulatory scenarios by the primary copper facilities generating the three special wastes. Next, the Agency discusses the cost implications of requiring these changes to existing waste management practices. The last part of this section of the chapter estimates and discusses the ultimate impacts of the increased waste management costs faced by the affected facilities.

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[80] Collins, R.J. and R.H. Miller, 1976, op. cit., pp. 150-151, 176, 182.

6.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented above, EPA believes that copper slag and copper calcium sulfate sludge may be EP toxic at some facilities. Accordingly, the Agency has estimated the costs associated with regulation under Subtitle C of RCRA, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus," as previously introduced in Chapter 2, and as described in specific detail below.

EPA has adopted a conservative approach in conducting its cost analysis for the wastes generated by the primary copper industry. For the two wastes that pose potential risk, the Agency has assumed that these materials would exhibit EP toxicity at all facilities unless actual sampling and analysis data demonstrate otherwise[81]. EPA's waste sampling data indicate that copper slag does not exhibit any characteristics of hazardous waste at all but one of the facilities that generate the material. The Agency's cost and impact analysis for slag is therefore limited to that one facility, Phelps Dodge/Playas, whose slag exhibited EP toxicity for cadmium and lead. Similarly, non-confidential sampling data are available from one of the two facilities generating calcium sulfate sludge; these data indicate EP toxicity for arsenic, cadmium, and selenium. Sludge from both facilities is assumed to be potentially hazardous, therefore, cost impacts for both facilities have been estimated. Costs and impacts have not been estimated for copper slag tailings, because the waste does not exhibit any of the four hazardous waste characteristics and appears to pose low overall hazard, as discussed above.

Copper Slag

Subtitle C

Under Subtitle C standards, generators of hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because copper slag is a solid, non-combustible material, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed of in waste piles, EPA has assumed in this analysis that the ultimate disposition of copper slag would be in Subtitle C landfills. Because, however, current practice at the potentially affected primary copper facility is disposal of slag in a wastepile, the Agency has assumed that the facility would also construct a small temporary storage waste pile (with capacity of one week's waste generation) that would enable the operator to send the slag to on-site disposal efficiently. To accommodate the large waste volume generated at the Playas facility (almost 365,000 mt/yr), EPA believes that the least-cost option would be for the facility operator to construct one on-site landfill that meets the minimum technology standards specified at 40 CFR 264, rather than ship the material off-site to a commercial hazardous waste landfill or build multiple landfills. Furthermore, EPA has adopted the conservative assumption that the operator of the smelter would continue to dispose of its slag, rather than attempt to recycle it. The Agency recognizes, however, that given the large quantities of material generated and the high cost of Subtitle C waste management (discussed more fully below), that the affected firm may well choose to recycle, or reduce the generation rates of its smelter slag.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-minus is the facility-specific application of requirements based on potential risk from the hazardous special waste. Under the C-minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating groundwater resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) will be necessary to protect human health and the environment. The Playas facility was determined to have a low potential to contaminate groundwater resources. Therefore, under Subtitle C-minus, the facility would be allowed to continue to operate its present disposal wastepiles, though run-on/run-off and wind dispersal/dust suppression controls are assumed to be required for the unit, as well as groundwater monitoring. In addition, the unit must undergo formal closure, including a cap of crushed stone, and post-closure care must be maintained (e.g., leachate/run-off collection and treatment, cap maintenance, and continued groundwater monitoring) for a period of thirty years.

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[81] An exception to this general approach concerns the anode furnace slag generated at the ASARCO-Amarillo and Phelps Dodge-El Paso facilities, both of which are stand-alone refineries. Because EPA has no sampling data on this specific component of copper slag, and because all anode furnace slag is recycled by all facility operators, the Agency has assumed that generators would not incur compliance costs related to management of this material in the absence of the Mining Waste Exclusion.

Subtitle D-Plus

As under both Subtitle C scenarios, the facility operator would, under the Subtitle D-plus scenario, be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to groundwater increases. As the Playas facility has low potential to contaminate groundwater resources, Phelps Dodge is assumed to be allowed to continue operating its disposal wastepile under Subtitle D-Plus. The wastepile would be retrofitted with run-on/run-off and wind dispersal/dust suppression controls which, as with Subtitle C-minus, must be maintained through closure and the post-closure care period. Groundwater monitoring and capping at closure is assumed to not be required for management units under Subtitle D-Plus when the groundwater contamination potential is low, though wind dispersal/dust suppression controls must be maintained.

Calcium Sulfate Wastewater Treatment Plant Sludge

Subtitle C

Under Subtitle C standards, generators of hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because copper calcium sulfate sludge is a slurry of non-combustible material, EPA has assumed in this analysis that the sludge would be treated and solidified/stabilized in dual Subtitle C treatment surface impoundments, and that the ultimate disposition of the stabilized sludge would be in a Subtitle C landfill. To accommodate the portion disposed, EPA believes that, because of cost considerations, each facility operator would construct two on-site treatment surface impoundments and one on-site landfill that meet the minimum technology standards specified at 40 CFR 264, rather than ship the material off-site to a commercial hazardous waste landfill.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-minus is the facility-specific application of requirements based on potential risk from the hazardous sludge. Under the C-minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating groundwater resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) would be necessary to protect human health and the environment. Both facilities generating potentially hazardous copper calcium sulfate sludge were determined to have a low potential to contaminate groundwater resources. Therefore, under Subtitle C-minus, both facilities would be allowed to continue to operate their present management units. Run-on/run-off controls are assumed to be required for the storage impoundments and disposal units. Groundwater monitoring would be required for both facilities and would continue through closure and the post-closure care period. In addition, the units must undergo formal closure, including a cap of crushed stone underlain by a run-on/leachate collection system to remove the rainfall and snowmelt that would be expected in short but intense surges. Post-closure care must be maintained (e.g., leachate/run-off collection and treatment, cap maintenance, and groundwater monitoring) for a period of thirty years.

In addition to the cost differences between full Subtitle C versus Subtitle C-minus that are attributable to the actual management units, an additional cost difference is associated with the relaxation of the sludge stabilization/solidification requirements. Sludges are assumed to be disposed without stabilization/solidification and the associated costs; in addition, the treatment units (i.e., settling ponds) used to separate sludge and entrained water prior to cementation are no longer required.

Subtitle D-Plus

As under both Subtitle C scenarios, facility operators under the Subtitle D-plus scenario would be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to groundwater increases. As the two copper facilities with potentially hazardous copper calcium sulfate sludge both have low potential to contaminate groundwater resources, the facilities are assumed to be allowed to continue operating their disposal units under Subtitle D-Plus. The management units would be retrofitted with run-on/run-off controls which must be maintained through closure and the post-closure care period. Capping the units with crushed stone underlain by a run-on/leachate collection system (i.e., the same as described in the Subtitle C-minus discussion above) is required and must be maintained through the post-closure care period. Groundwater monitoring would not be required for these units because of the low groundwater contamination potential.

In addition to the cost differences between full Subtitle C and Subtitle D-Plus that are attributable to the actual management units, an additional cost difference is associated with the relaxation of the sludge stabilization/solidification requirements. Sludges are assumed to be disposed without stabilization/solidification and its associated costs; in addition, the treatment impoundments (i.e., settling ponds) used to separate sludge and entrained water prior to cementation are no longer required.

6.6.2 Cost Impact Assessment Results

Copper Slag

Results of the cost impact analysis for the Playas smelter are presented for each regulatory scenario in Exhibit 6-11. Under the Subtitle C scenario, Phelps Dodge's annualized regulatory compliance costs are estimated to be just over $8.6 million more than baseline waste management costs (about 17 times greater). Over $6.7 million of the increased compliance costs would be for new capital expenditures, or approximately 78 percent of the total.

Under the facility specific risk-related requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about 82 percent less than the full Subtitle C costs. Phelps Dodge's annualized compliance costs would be $1.1 million more than the baseline waste management costs (about 3 times greater than baseline). The primary savings over the full Subtitle C costs, due to the consideration of risk potential, are the relaxation of technical requirements and the ability to use disposal wastepiles. New capital expenditures, nearly 95 percent less than under full Subtitle C, would account for about $362,000 of the incremental C-Minus compliance costs (about 34 percent of the annualized compliance cost).

Regulation under the Subtitle D-Plus program is assumed to require the same management controls as under Subtitle C-Minus, with the exception that, because of the low risk classification, no groundwater monitoring or capping at closure is required under this scenario. Phelps Dodge's annualized regulatory compliance costs would be $471,000 more than the baseline waste management costs (about 2 times the baseline cost). This represents a decrease of 89 percent from the Subtitle C compliance costs, and a decrease of 38 percent from the Subtitle C-Minus compliance costs.

Exhibit 6-11
Compliance Cost Analysis Results for Management of Copper Slag from Primary Processing[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Phelps Dodge - Playas, NM	532	8,611	45,312	6,761	1,077	2,424	362	471	970	145
Total:	532	8,611	45,312	6,761	1,077	2,424	362	471	970	145

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Costs have been estimated only for facilities for which sampling data indicate that the waste would exhibit a RCRA hazardous waste characteristic.

Copper Calcium Sulfate Sludge

Only two primary copper plants generate calcium sulfate sludge: Kennecott/Garfield, and ASARCO/Hayden. Costs associated with regulatory compliance are shown in Exhibit 6-12. Both facilities would incur costs under the Subtitle C scenario, with Kennecott/Garfield facing annualized compliance costs of more than $10.0 million and ASARCO/Hayden almost $5.2 million. These costs represent increases of almost 10 times current waste management costs. Annualized capital expenditures account for about half of annualized compliance costs, at about $5.0 million at Kennecott/Garfield and $2.2 million at ASARCO/Hayden. Other significant contributors to the increase in waste management costs include cement stabilization costs (which are mostly an operating cost) and the costs of operating double lined settling ponds and landfills.

Under the Subtitle C-Minus scenario, annualized compliance costs are estimated at $1.2 million for Kennecott/Garfield, and $0.45 million for ASARCO/Hayden (about twice the baseline costs), a decrease for the sector as a whole of 90 percent from the Subtitle C scenario. Relaxation of cementation requirements, and the ability, due to low risk potential, to continue to operate their storage and disposal units with retrofitted controls (e.g., run-on/run-off controls) account for the extremely large cost savings over the full Subtitle C regulatory scenario.

Under the Subtitle D-Plus regulatory scenario, compliance-related waste management costs are 93 percent lower than Subtitle C, for the same reasons that Subtitle C-minus was less costly (e.g., no cementation, no new units required). Costs were nearly 40 percent less than Subtitle C-minus, however, primarily because the requirement for groundwater monitoring is waived for units located in low risk environments under this scenario.

6.6.3 Financial and Economic Impact Assessment

To evaluate the ability of affected facilities to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of each facility (in the form of financial impact ratios) to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic copper producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the copper industry. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in Appendices E-3 and E-4 to this document, while detailed results are presented in Appendix E-5.

Financial Ratio Analysis

Copper Slag

EPA believes that Subtitle C regulation might impose significant financial impacts on the Playas facility. As shown in Exhibit 6-13, the annualized incremental costs associated with waste management under Subtitle C represent a significant portion of the value added (more than eight percent) by the Playas smelter. Moreover, the ratio of annualized compliance capital costs to annual sustaining capital investments also suggests a substantial economic impact.

Financial impacts under the Subtitle C-Minus scenario are much less severe than those under the full Subtitle C scenario. The compliance costs as a percent of value added and value of shipments indicate only slight impacts. In addition, compliance capital needs as a percent of sustaining capital are low, at less than 2 percent.

Exhibit 6-12
Compliance Cost Analysis Results for Management of Calcium Sulfate WWT Plant Sludge from Primary Copper Processing[a]

	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
Facility	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Kennecott - Garfield, UT	1,115	9,960	33,225	4,958	1,182	3,589	535	704	2,567	383
Asarco - Hayden, AZ	539	5,187	15,075	2,249	453	512	76	310	370	55
Total:	1,654	15,147	48,300	7,207	1,635	4,100	612	1,014	2,937	438
Average	827	7,574	24,150	3,603	818	2,050	306	507	1,469	219

[a] Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Exhibit 6-13

Significance of Regulatory Compliance Costs for Management of Copper Slag from Primary Processing[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Phelps Dodge - Playas, NM	2.6%	8.4%	34.1%
Subtitle C-Minus			
Phelps Dodge - Playas, NM	0.3%	1.1%	1.8%
Subtitle D-Plus			
Phelps Dodge - Playas, NM	0.1%	0.5%	0.7%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays

Costs and impacts have been estimated for only those facilities for which sampling data indicate that the waste exhibits a RCRA hazardous waste characteristic.

(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Financial impacts under the Subtitle D-Plus scenario decrease even from the Subtitle C-minus impacts; the Playas facility would not be expected to be substantially affected under this regulatory scenario. The compliance costs as a percent of value added and value of shipments indicate very low impacts to the facility. Compliance capital needs as a percent of sustaining capital are negligible as well, at less than three quarters of one percent.

Calcium Sulfate Wastewater Treatment Plant Sludge

EPA believes that Subtitle C regulation might impose significant financial impacts on the Kennecott and Hayden facilities. As shown in Exhibit 6-14, the annualized incremental costs associated with waste management under Subtitle C represent a significant portion of both the value added and the value of shipments for both facilities generating calcium sulfate sludge. Moreover, the ratio of annualized compliance capital costs to annual sustaining capital investments also suggests potentially significant impacts for these facilities.

Financial impacts under the Subtitle C-Minus scenario are much less severe than full Subtitle C impacts. Compliance costs as a percent of value added and value of shipments indicate only slight impacts at worst (one percent or less). Compliance capital needs as a percent of sustaining capital are also relatively low, at less than 3 percent.

Financial impacts under the Subtitle D-plus scenario decrease even from the Subtitle C-minus impacts; the two facilities are not expected to be significantly affected under this regulatory scenario.

Exhibit 6-14
Significance of Regulatory Compliance Costs for Management of Calcium Sulfate WWT Plant Sludge from Primary Copper Processing[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Kennecott - Garfield, UT	2.6%	8.4%	21.4%
ASARCO - Hayden, AZ	1.7%	5.4%	12.1%
Subtitle C-Minus			
Kennecott - Garfield, UT	0.3%	1.1%	2.3%
ASARCO - Hayden, AZ	0.1%	0.5%	0.4%
Subtitle D-Plus			
Kennecott - Garfield, UT	0.2%	0.6%	1.7%
ASARCO - Hayden, AZ	0.1%	0.3%	0.3%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays

[a] Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Market Factor Analysis

General Competitive Position

There have been extensive structural changes in the U.S. copper mining and processing industry since the recession of the early 1980s. Coupled with the massive oil industry purchase and divestiture of copper facilities in the late 1970s and mid 1980s, respectively, the present U.S. copper industry looks very different from the U.S. copper industry of a decade ago. The major changes have included:

1. Closure of high-cost mining operations;
2. Modification of mining plans at operating mines that allow for lower cost exploitation of mineral values. Generally this reflects a decrease in stripping ratios or an increase in cut-off grade;
3. Extensive mechanization of mines, including modification of haulage methods;
4. Modernization of milling methods to improve scale economies and recovery;
5. Closure of several high-cost, non-competitive smelters;
6. Improvements in new smelter technology and environmental controls; and,
7. Increases in the production of low-cost solvent extraction-electrowinning (SX-EW) copper.

These technical advances and competitive business decisions were coupled with extensive labor negotiations that checked union wage increases and often rolled back benefits, particularly in the pension area. Along with these labor agreements have been concessions by mines to share the profits and benefits from increased productivity.

Since 1982, when the U.S. provided 17 percent of the world copper mine supply, the domestic copper industry has rebounded to become a major mine producer, currently producing 21 percent of world supply. Substantial increases in the price of copper and the expansion and modernization of the Bingham Canyon (Garfield) mine and smelter complex in Utah have fueled the increase in copper production.

U.S. consumption has returned to the high levels of the late 1970s and early 1980s but still accounts for only about 27 percent of world consumption as opposed to 30 percent in the late 1970s. U.S. facilities (including secondary producers) are again accounting for over 80 percent of domestic requirements.

Potential for Compliance Cost Pass-Through

Labor Markets

Approximately 12,000 workers were employed in the copper sector in 1988, with an average salary of $28,539. Imposing substantially lower wages to counteract compliance costs is not a likely scenario in the copper processing industry. There have already been significant wage and benefit concessions and movement in the opposite direction with regard to wages is likely over the next few years.

Raw Material Supply Markets

Because recent mergers and property acquisitions in the U.S. industry have resulted in extensive vertical integration, the reduction of prices paid to suppliers is basically an accounting exercise (i.e., shifting expenses from one profit center within a corporation to another). In addition, if copper producers are unable to use the ore that the company generates to produce copper at competitive prices, they can instead sell the concentrate on the world market. In fact, export of concentrate is already occurring; because smelter capacity is less than concentrate production levels, excess U.S. concentrate production is largely exported (approximately 15 percent of domestic mine production was exported in the form of concentrate in 1989).

In the case of suppliers which have concentrate and little smelter capacity, there may be some opportunity to lower prices for their concentrate to compensate for higher compliance costs on the smelter/refinery level. This will depend largely on costs at foreign smelters (including transport of concentrate to the smelters) and whether low costs will allow foreign firms to outbid U.S. smelters for concentrate. If the cost impacts on smelters and refineries are significant, several mines in the U.S. will be able to export their concentrate on favorable terms, though their profit margins will be reduced.

Higher Prices

The copper metal market is a world market and, therefore, U.S. prices must be in line with world prices. The U.S. producers enjoy only a marginal transport cost advantage in supplying U.S. domestic markets, so that significant price increases are not possible. More importantly, only three of the ten domestic facilities that produce refined primary copper would experience increases in waste management costs in the absence of the Mining Waste Exclusion. It is extremely unlikely that these three facilities could successfully pass through compliance costs to domestic consumers (even though in combination they account for more than 40 percent of domestic supply), given the structure of domestic and global copper markets.

Evaluation of Cost/Economic Impacts

All three facilities that generate a potentially hazardous special waste from primary copper processing are expected to incur significant impacts under full Subtitle C regulation; Subtitle C-Minus with its regulatory flexibility, however, would allow for RCRA Subtitle C regulation of these waste with significantly less, and in some cases only marginal, financial impacts. Due to the international nature of the market, and the fact that only one (if only slag is regulated) to three (if both slag and sludge are regulated) facilities would be affected, producers experiencing regulatory impacts would be unlikely to be able to raise prices enough, if at all, to pass through their compliance costs. Consequently, EPA believes that any incremental waste management costs incurred by facilities as a result of a change in the regulatory status of the special wastes will be borne entirely by these facilities. Nonetheless, because of the regulatory flexibility imparted by RCRA §3004(x), the Agency does not believe that the continued profitability or long-term viability of the affected primary copper facilities would necessarily be threatened by a change in the regulatory status of copper slag or calcium sulfate wastewater treatment plant sludge.

6.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Copper Slag

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of copper slag is moderate compared to the other mineral processing wastes studied in this report. Data collected by EPA and submitted by industry indicate that most copper slag does not exhibit any of the characteristics of hazardous waste, and hence, would not be subject to Subtitle C regulation if it were to be removed from the Mining Waste Exclusion. However, at one facility (out of seven that were tested), sampling data suggest that copper slag may exhibit the hazardous waste characteristic of EP toxicity -- one sample of the 70 available to EPA for this study contained cadmium and lead in excess of the EP toxicity regulatory levels. None of the slag samples that were analyzed using the SPLP leach test (EPA Method 1312), however, contained constituents in concentrations that exceed the EP toxicity regulatory levels. In addition, copper slag contains seven constituents at levels that exceed the risk screening criteria used in this analysis by a factor of 10. All of these factors lead EPA to conclude that copper slag could pose a moderate risk if mismanaged.

Based on an examination of the characteristics at the 10 active primary copper facilities and predictive modeling, EPA believes that copper slag poses a low risk at most facilities. Almost all of the facilities are located in areas with generally low-risk environmental and exposure characteristics (e.g., very low precipitation and net recharge, large depths to ground water, minimal use of nearby surface and ground-water resources, and great distances to potentially exposed populations). A possible exception is the facility in White Pine, MI. Using the conditions at White Pine as a conservative model, EPA predicts low risks associated with potential dispersal of slag contaminants in ground water and air. Erosion of contaminants into nearby surface waters, however, could cause greater impacts. The Agency predicts that stormwater erosion from a copper slag pile, if not controlled, could result in annual average surface water concentrations of lead, iron, and molybdenum that exceed MCLs or irrigation guidelines, as well as copper concentrations that exceed criteria for the protection of aquatic life. Surface water contamination of this magnitude, however, should not actually occur at the White Pine facility because the slag dump at that facility is equipped with stormwater run-on/run-off controls. Similarly, significant surface water contamination is not expected at the other sites because the nearest surface waters are farther away and have a greater assimilative capacity than that reflected by the conservative conditions that were modeled.

Documented damage cases also show that run-off from copper slag can contaminate surface waters. In some cases, such problems have been eliminated through revised slag management practices, such as collection and treatment of the run-off. At the Commencement Bay Superfund site, however, where slag was used as ballast in a wet, low-lying area, control of the contaminated run-off has been more difficult. Documented cases of damage to ground water at copper smelters was also identified. In all cases, however, the extent to which slag is contributing to the contamination is unclear and there are more probable sources of the observed contamination, such as unlined wastewater impoundments.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

At the 10 active copper facilities, the current waste management practices and environmental conditions are expected to limit contaminant migration and exposures in the future in the absence of more stringent Federal regulation. Only one of the active slag piles is lined with a synthetic material (asphalt), only five are equipped with storm water run-on/run-off controls, and dust suppression is practiced at only two of the piles. However, the potential for significant releases to ground and surface water is limited by the extremely arid setting of most sites; in addition, the potential for significant airborne releases is limited by the large particle size of the slag. The primary exception to this generalization is the potential for stormwater erosion into surface water next to the White Pine facility, but the slag pile at this site is equipped with run-off controls that should limit releases through that pathway. Conceivably, exposures could occur at these sites in the future if people moved closer to the waste management units in the future or if ground water very near the units is ever used (assuming that there is useable ground water in the arid settings of most sites). However, considering the relatively moderate intrinsic hazard of this waste, significant exposures at these sites are generally not expected.

There is a potential for the slag to be generated and managed at alternate sites that could be more conducive to releases and risks than the 10 active copper facilities. Several companies have announced plans for expanding existing facilities and building new facilities in entirely new locations (such as Texas City, TX). In addition, there are numerous historical and on-going uses of copper slag at off-site locations, such as use as a highway construction aggregate, a portland cement replacement in concrete, highway embankment material, road or railroad ballast, and as grit in abrasive airblasting. For some off-site uses, such as road sanding, health and environmental concerns have been raised and the use has been discontinued. For other uses, such as airblast abrasive, little if any information on the health and environmental impacts appears to be available. Presumably because most copper slag is generated and used in relatively arid areas of the country, the Commencement Bay log-sort yards are the only known example of damages resulting from off-site use.

The active copper processing facilities that generate slag are located in five states (Texas, Arizona, Utah, Michigan, and New Mexico), all of which adopt the federal hazardous waste regulatory exclusion for mineral processing wastes. The majority of these states do not vigorously regulate mineral processing wastes in general, or copper slag in particular, under their solid waste regulations, even if there are provisions that would allow them to do so. For example, both Utah and New Mexico specifically exempt mineral processing wastes from their solid waste regulations. Moreover, Michigan apparently exempts copper slag generated at the White Pine facility from solid waste regulation because the slag is reprocessed. Although Texas classifies mineral processing wastes as industrial solid wastes, the copper processing facilities currently generating slag are only required to notify the state of their waste management activities. All of the states appear to address some or all of the copper processing wastes to some extent under surface water discharge permitting programs. Both Arizona and New Mexico also have ground-water discharge permit programs, and Utah recently enacted ground-water protection legislation that will require permits. Finally, although all of the states appear to have fugitive dust emission control requirements that could apply to copper slag, the extent to which these requirements are being applied to the slag is not clear.

Costs and Impacts of Subtitle C Regulation

Because of the moderate intrinsic risk potential of this waste and the fact that EPA waste sampling data indicate that copper slag may exhibit the hazardous waste characteristic of EP toxicity, the Agency has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. Because, however, data available to EPA indicate that copper slag is not EP toxic at most of the facilities that generate it, the Agency has assumed that this waste would be EP toxic (hence, affected by a change in regulatory status) at only the one facility (Phelps Dodge-Playas) at which a sample indicates exceedances of EP toxicity regulatory levels.

Total costs of regulatory compliance at the Playas copper plant exceed $8.6 million annually under the full Subtitle C scenario, while under the flexible standards of the Subtitle C-Minus scenario, costs would be 82 percent lower, at just over $1 million per year. Under the Subtitle D-Plus scenario, annual compliance costs at the Playas facility would be less than $500,000, a 38 percent reduction from Subtitle C-Minus cost impacts. Full Subtitle C compliance costs represent more than eight percent of the value added by the affected facility, while impacts of the less stringent regulatory scenarios are modest. EPA's economic impact analysis suggests that the operator of the potentially affected facility would have difficulty passing through any portion of regulatory compliance costs that it might incur to product consumers, because it accounts for less than 15 percent of domestic production and would be the only facility expected to incur regulatory compliance costs if copper slag were to be removed from the Mining Waste Exclusion. Therefore, EPA believes that the operators of the Playas facility would have to bear in full any incremental costs associated with regulation of copper slag under Subtitle C, but that the associated impacts under modified Subtitle C standards would not threaten the continued viability of this facility.

Copper Slag Tailings

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of copper slag tailings is relatively low compared to the other mineral processing wastes studied in this report. The tailings do not exhibit any of the four characteristics of hazardous waste, and only 5 constituents were detected in the tailings in concentrations that exceed the conservative risk screening criteria used in this analysis by a factor of 10 or more.

Based on the Agency's review of existing management practices and release/exposure conditions, as well as the lack of documented cases of damage caused by copper slag tailings, the overall hazard associated with management of the tailings appears to be low. Although the tailings are generated as a slurry and co-managed with liquids that could serve as a leaching medium, the concentrations of only three contaminants in the leachate exceed the screening criteria by a factor of 10 or greater. Furthermore, ground water at the three facilities that actively generate and manage the tailings is either very deep (and thus somewhat protected) or currently is not used within a mile downgradient of the waste disposal site. It is possible, however, that ground water close to the slag tailings units could be used sometime in the future. Except for the White Pine facility, where there is a moderate potential for the tailings to migrate to surface water, the potential for the tailings to cause significant surface water contamination appears very remote. Airborne dusting from the tailings piles can and does occasionally occur. Windblown dust from the piles should be studied further and, if necessary, controlled to prevent possible inhalation exposures to arsenic and chromium.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

In the absence of more stringent federal regulation, there will continue to be a potential for slag tailings contaminants to migrate into ground water, surface water, and air at some of the active facilities. However, considering the relatively low intrinsic hazard of the tailings, significant exposures at these sites would not be expected unless ground water very near the tailings piles is used or if people moved very close to the piles in the future. The tailings are susceptible to wind erosion when dry, and windblown dust after closure could be a problem, especially in the arid settings of two of the plants. EPA believes that, after closure, measures should be taken to control windblown dust and associated potential inhalation risks to existing and potential future populations.

There is only a slight potential for the tailings to be generated and managed at alternate sites in the future. As discussed above for copper slag, some companies have announced plans to construct new copper processing facilities, but it is uncertain if any of the new facilities would generate slag tailings (not all copper facilities generate slag tailings). Also, given the quantities of tailings involved, it is unlikely that the tailings would be disposed off-site. Slag tailings have been used off-site in the past for highway embankment material and road base, and thus it is conceivable that the tailings could be used off-site again in the future. None of the facilities that currently generate the tailings, however, ship the tailings off-site for use.

The three copper processing facilities that generate slag tailings are located in Arizona, Utah, and Michigan, all of which exclude copper slag tailings from regulation as hazardous waste. In addition, none of these states vigorously regulate mineral processing wastes in general, or copper processing wastes in particular, under their solid waste regulations. For example, Utah specifically exempts mineral processing wastes from its solid waste regulations. Arizona has a ground-water discharge permit program, and Utah recently enacted ground-water protection legislation that will require permits. All three states appear to have general fugitive dust emission control requirements that could apply to copper processing wastes, but the extent to which these requirements are being applied is not clear.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of copper slag tailings, the complete absence of documented damages associated with the management of this material, and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating copper slag tailings under RCRA Subtitle C.

Calcium Sulfate Wastewater Treatment Plant Sludge

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of calcium sulfate wastewater treatment plant sludge from copper processing is relatively high compared to the other mineral processing wastes studied in this report. Although none of the sludge samples that were analyzed using the SPLP leach test (EPA Method 1312) contained constituents in concentrations above the EP toxicity regulatory levels, several sludge samples analyzed with the EP leach test were found to be EP toxic. Arsenic and selenium were measured in EP leachate in excess of the EP toxicity regulatory level in seven out of seven samples (from the one facility tested). Cadmium was also measured in EP leachate in excess of the EP toxicity level in six out of seven samples. In addition to these exceedances of the EP toxicity regulatory levels, calcium sulfate sludge contains 10 constituents in concentrations that exceed the risk screening criteria used in this analysis by more than a factor of 10. All of these factors lead EPA to conclude that the sludge could pose a significant risk if mismanaged.

Based on a review of existing management practices and facility settings, as well as predictive modeling results, EPA believes that the hazards associated with calcium sulfate sludge are generally low at the two facilities where it is currently generated. Both facilities are located in very arid locations (Hayden, AZ and Garfield, UT) where there is little precipitation and recharge to ground water. Even the liquids used to slurry the sludge into the impoundments are expected to quickly evaporate, rather than seep into the ground. Considering this lack of water to carry sludge contaminants to the subsurface, along with the depths to ground water and the tendency of the sludge contaminants to bind to soil, EPA predicts that it would take more than 200 years for contaminants to migrate from the sludge into ground water. If the impoundment at the Hayden facility is conservatively assumed to be filled with sludge and not equipped with a cover or storm water run-off control system, the Agency predicts that erosion from the impoundment could cause arsenic and silver concentrations in the nearby Gila River that exceed health and ecological protection benchmarks. However, because the impoundment at Hayden is in fact equipped with run-off controls, surface water contamination of this magnitude is not actually expected. The potential for significant releases of windblown dust from the sludge appears very remote, because the surface of the sludge dries to form a crust that is relatively resistant to wind erosion.

No cases of documented damage caused by the sludge were discovered by EPA. This finding supports the conclusion that, as currently managed, the sludge poses a generally low hazard.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

Even though the intrinsic hazard of calcium sulfate sludge is high, the risks at the two facilities that currently generate the sludge are expected to remain low in the future in the absence of more stringent federal regulation. This is because the sludge appears to be reasonably well managed at present, and the potential for significant releases and exposures is generally precluded by the environmental conditions at these two sites.

However, there is a potential for the sludge to be generated and managed at alternate sites in the future, especially if the sludge is not regulated under Subtitle C of RCRA. As discussed previously, several companies have announced plans to expand production capacity at existing sites and to construct new copper processing facilities in entirely new locations. Some of these new facilities and locations may be more conducive to releases and risks than the two active sites. Also, although the sludge has not been used or disposed off-site in the past and there are no plans to ship the sludge off-site in the near future, any off-site shipments of the sludge could pose a significant risk if the sludge is not properly managed.

The existing regulatory programs in Arizona and Utah provide only limited controls over the management of calcium sulfate sludge from copper processing. Both states exempt the sludge from hazardous waste regulation, and neither state vigorously regulates the sludge under its solid waste regulations. In fact, Utah specifically exempts mineral processing wastes from its solid waste regulations. Arizona classifies the sludge as solid waste, but to date has not focused its regulatory efforts on the facilities under study. However, Arizona does have a ground-water discharge permit program, and Utah recently enacted ground-water protection legislation that will require permits. In addition, both states appear to have general fugitive dust emission control requirements that could apply to calcium sulfate sludge, but the extent to which these requirements are being applied is not clear.

Cost and Impacts of Subtitle C Regulation

EPA has evaluated the costs and associated impacts of regulating calcium sulfate wastewater treatment plant sludge from primary copper production as a hazardous waste under RCRA Subtitle C. EPA's waste characterization data indicate that this waste exhibits the hazardous waste characteristic of EP toxicity at the one (of two) active facilities for which sampling data were available. EPA has employed the conservative assumption that the calcium sulfate sludge would also be EP toxic at the other (ASARCO-Hayden) facility; the Agency's cost and impact estimates reflect this assumption and therefore may overestimate the impacts of prospective regulation.

Costs of regulatory compliance under the full Subtitle C scenario exceed $5 million annually at both facilities; these costs would impose potentially significant economic impacts on the operators of the affected plants. Application of the more flexible Subtitle C-Minus regulatory scenario would result in compliance costs that are about 90 percent lower, ranging from about $450,000 to just under $1.2 million annually. Costs under the Subtitle D-Plus scenario are approximately 40 percent lower than under Subtitle C-Minus, because of further relaxation of waste management unit design and operating standards.

Subtitle C compliance costs would comprise a significant fraction of the value added by copper smelting/refining operations at both affected facilities; this ratio exceeds eight percent at the Garfield facility and five percent at the Hayden plant. Compliance cost ratios under the Subtitle C-Minus and Subtitle D-Plus scenarios are substantially lower, not exceeding one percent at either facility. EPA's economic impact analysis suggests that the domestic copper industry is currently stronger than it has been in recent years, but would have limited ability to pass through compliance costs in the form of significantly higher prices to product consumers. Moreover, because not all domestic producers would be affected or affected equally (the two potentially affected facilities account for about 30 percent of domestic capacity), it is improbable that the affected facilities would be able to obtain higher product prices in any case. Nonetheless, given the moderate impacts predicted under the flexible management standards of the Subtitle C-Minus scenario, EPA believes that a decision to remove calcium sulfate sludge from the Mining Waste Exclusion would not threaten the long-term profitability and hence, economic viability, of the facilities generating this waste.

Finally, EPA is not aware of any significant recycling or utilization initiatives that would be hampered by a change in the regulatory status of this waste. To date, there have not been any attempts to develop management alternatives to disposal. Impacts on the Agency-wide policy objective of waste minimization are unclear. Calcium sulfate sludge is a pollution control residual that is generated by the treatment of acid plant blowdown and process wastewaters at primary copper smelter/refineries. Because these aqueous waste streams often exhibit characteristics of hazardous waste and have themselves been recently removed from the Mining Waste Exclusion, they will in the future require treatment under RCRA Subtitle C standards. If calcium sulfate sludge were to be regulated as a hazardous waste, facility operators might be more inclined to use treatment methods that generate lesser quantities of more concentrated sludge (e.g., by using caustic instead of lime). In this way, the total quantity of hazardous waste requiring disposal would decrease, though the inherent hazard posed by the treatment sludge would increase. The Agency plans to explore this issue further prior to the Regulatory Determination.

Chapter 7
Elemental Phosphorus Production

The elemental phosphorus industry consists of five facilities that, as of September 1989, were active and reported generating a mineral processing special waste: furnace slag. The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

7.1 Industry Overview

Elemental phosphorus is used solely as a process input to produce a wide array of phosphorus chemicals. As a chemical manufacturing feedstock, it may be used directly, or oxidized and condensed to produce a high-purity "furnace-grade" phosphoric acid. Furnace-grade acid, in turn, is a feedstock for the production of sodium phosphates, such as sodium tripolyphosphate, a detergent builder, which historically has been a major product, and additional sodium phosphates (e.g., trisodium phosphate, sodium hexametaphosphate, tetrasodium pyrophosphate) which are used in cleaners, water treatment, and foods.[1] Furnace-grade acid is also used to manufacture calcium phosphates for animal feed, dentifrices, foods, and baking powders. Another grade of furnace process acid is technical-grade acid, which is primarily used to clean metals.

The five elemental phosphorus production facilities are located near phosphate rock reserves in areas where the cost of the large amount of energy required to operate the furnaces is relatively low. Facilities are found in central Tennessee, Montana, and Idaho (see Exhibit 7-1). The dates of initial operation for these facilities range from 1938 at Mt. Pleasant to 1952 at Soda Springs and Columbia. Except for the Silver Bow facility, all facilities report having modernized their production operations; the Soda Springs facility was upgraded in 1978 and the remaining three plants were modernized in 19[illegible].[2] The reported 1988 elemental phosphorus production for the sector was 311,000 metric tons.[3] The sector-wide capacity utilization was, therefore, 91 percent during that year. Capacity data are presented in Exhibit 7-1.

Exhibit 7-1
Domestic Elemental Phosphorus Producers

Owner/Operator	Location	Capacity[(a)] (metric tons)[(b)]
FMC Corporation	Pocatello, ID	125,000
Monsanto Company	Soda Springs, ID	86,000
Occidental Chemical	Columbia, TN	52,000
Stauffer[(c)]	Mt. Pleasant, TN	41,000
Stauffer[(c)]	Silver Bow, MT	38,000

(a) SRI International, 1987. Directory of Chemical Producers--United States, 1987 Ed.; p. 869.
(b) Capacity data is on a P_4 basis.
(c) Rhone-Poulenc is the parent company.

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[1] Bureau of Mines, 1985 and 1987. Minerals Yearbook, 1987 Ed.; p. 677., and Mineral Facts and Problems, 1985 Ed.; p. 584.

[2] FMC Corp., Monsanto Co., Occidental Chemical Co., Stauffer Chemical Co. 1989. Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

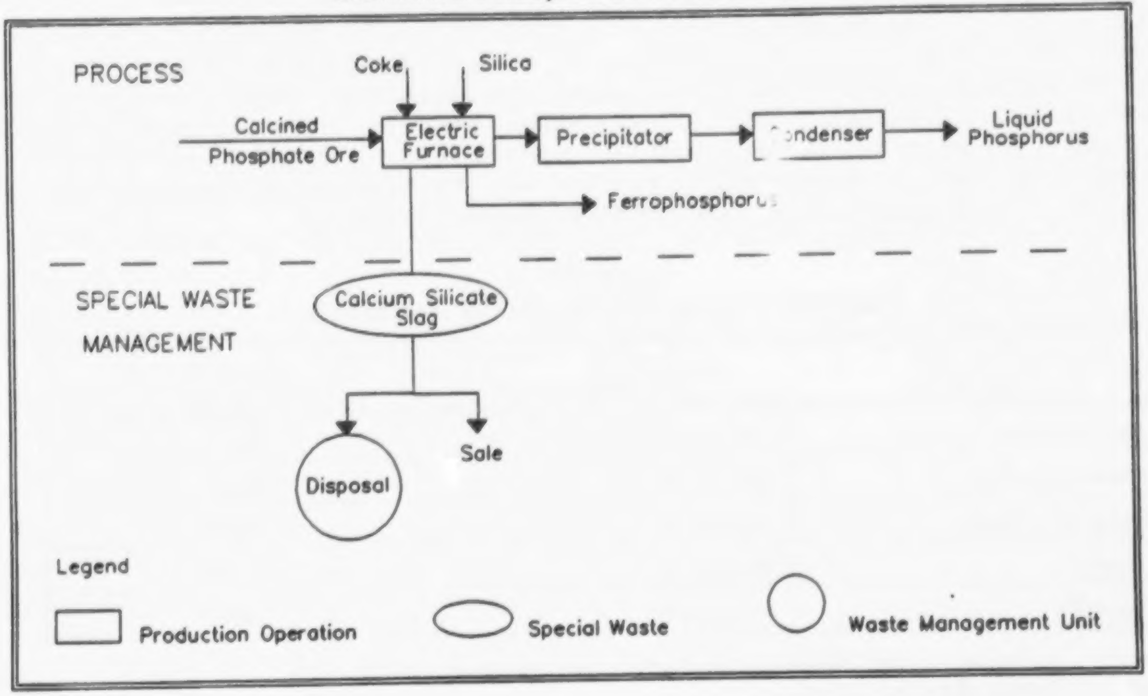
[3] Production statistics reported by three of the five facilities in the elemental phosphorous industry are confidential; because the three facilities are each owned by a different company, however, summary statistics for the sector can be reported without disclosing the facility-specific confidential data.

Production of phosphate rock has steadily increased since 1986, when production fell off by more than 10 percent of the 1985 total. Most of the increase in production throughout the late 1980s however, was due to phosphate rock sold or used for wet process phosphoric acid production. The quantity of phosphate rock used in domestic elemental phosphorus production actually decreased from 3.2 million metric tons in 1986 to 3.0 million metric tons in 1987.[4]

In elemental phosphorus production, sized phosphate rock or sintered/agglomerated phosphate rock fines are charged to (introduced into) an electric arc furnace together with coke (a reducing agent) and silica (a flux), as shown in Exhibit 7-2.[5] The phosphorus contained in the rock is both liberated from the rock matrix and chemically reduced by the operation.

The process generates calcium silicate slag and ferrophosphorus, which are tapped from the bottom of the furnace in molten form, and carbon monoxide (CO) off-gases, which contain volatilized phosphorus. The gas is treated using a precipitator to remove impurities and the cleaned gas, still containing the gaseous phosphorus, is condensed using water to produce liquid elemental phosphorus. Following this treatment step, the off-gas is typically routed to the ore sintering furnaces for use as fuel, though it may also be treated and released. Treatment residuals (e.g., off-gas solids) are either recycled or disposed. The molten residues are either air- or water-cooled, (i.e., solidified). Ferrophosphorus is typically sold as a byproduct. The calcium silicate furnace slag, the special mineral processing waste, is generally accumulated in storage piles, then sold and/or disposed.

Exhibit 7-2
Elemental Phosphorus Production


PROCESS
Coke
Silica
Calcined Phosphate Ore
Electric Furnace
Precipitator
Condenser
Liquid Phosphorus
Ferrophosphorus
SPECIAL WASTE MANAGEMENT
Calcium Silicate Slag
Disposal
Sale
Legend
Production Operation
Special Waste
Waste Management Unit

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[4] William F. Stowasser, U.S. Bureau of Mines, "Elemental Phosphorus," Minerals Yearbook, 1987 Ed., p. 679.

[5] Environmental Protection Agency, 1984. Evaluation of Waste Management for Phosphate Processing. Prepared by PEI Associates for U.S. EPA, Office of Research and Development, Cincinnati, OH; August, 1986.

7.2 Waste Characteristics, Generation, and Current Management Practices

The mineral processing special waste generated by elemental phosphorus production, furnace slag, is a solid material at ambient temperatures, although it usually is generated in a molten form. The slag is typically a light gray, heavy, extremely hard, and porous material. After cooling from its molten state, the slag is broken into cobble-to-boulder-size fragments. EPA analyses of this waste indicate that the solidified slag is a glass-like material that contains its constituents in a vitrified matrix. Elemental phosphorus slag is composed primarily of silicon and calcium and may contain radionuclides, including thorium-232, uranium-238, and decay products of these two radionuclides, such as radium-226.

Using available data on the composition of elemental phosphorus slag, EPA evaluated whether this waste exhibits any of the four hazardous waste characteristics: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information, EPA does not believe that elemental phosphorus slag exhibits any of the four characteristics of hazardous waste. Data are available on the concentrations of all eight inorganics with EP toxicity regulatory levels and, with the exception of chromium, all of these constituents are present in EP leachate in concentrations that are at least two orders of magnitude below the regulatory level, that is, below drinking water levels. The maximum chromium concentration observed in the leachate is one order of magnitude below the EP toxicity regulatory level.

Furnace slag generation rate data were reported as non-confidential information by two of the five elemental phosphorus production facilities, Columbia and Silver Bow, who reported waste generation rates of approximately 354,000 and 272,000 metric tons, respectively. The aggregate industry-wide generation of slag by the five facilities was approximately 2.6 million metric tons in 1988, yielding a facility average of over 526,000 metric tons per year.[6] The sector-wide ratio of metric tons of slag to metric ton of elemental phosphorus was 8.4 in 1988; waste-to-product ratios ranged from 8.0 (average for the three facilities submitting confidential information) to 10.0 (at each of the other two facilities).

Two management practices predominate throughout the sector: 1) the sale of the slag for use as a construction material (e.g., as an aggregate) and 2) storage or disposal of the furnace slag in waste piles. Three facilities sold from 35 to 43 percent of the slag that they generated in 1988; the remainder of the slag was placed in "stockpiles." Of the two remaining facilities, the Columbia plant reported selling all of its slag, while the Silver Bow facility reported disposing all of its slag in a "slag pile." In 1988, the quantity of slag sent to disposal waste piles at the five facilities ranged from 0 to greater than 500,000 metric tons per facility, averaging 320,000 metric tons. As of 1989, stockpile areas at the five facilities ranged from 5 to 38 hectares (12 to 95 acres) per facility. The total quantity of slag accumulated in these piles in 1988 ranged from 1,500,000 to 21,000,000 metric tons per facility.[7]

With regard to environmental media protection controls, only the Soda Springs, Idaho, facility reports practicing dust suppression on its on-site waste piles, and none of the facilities report the use of liners or leachate collection systems to limit infiltration through the piles.

7.3 Potential and Documented Danger to Human Health and the Environment

In this section, EPA discusses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health and/or the environment has been proven. Overall conclusions about the hazards associated with elemental phosphorus slag are based on these two study factors and are presented at the end of this section.

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[6] Waste generation data that three facilities requested be confidential can be summed together and presented without revealing confidentiality, as the three facilities are owned by different companies.

[7] Stockpile area and accumulated quantity were not reported for two of the facilities.

7.3.1 Risks Associated With Elemental Phosphorus Slag

Any potential danger to human health and the environment posed by elemental phosphorus furnace slag depends on the presence of hazardous constituents in the slag and the potential for exposure to these constituents.

Constituents of Concern

EPA identified chemical constituents in furnace slag that may present a hazard by collecting data on the composition of the slag and evaluating the intrinsic hazard of the slag's constituents.

Data on Elemental Phosphorus Slag Composition

EPA's characterization of elemental phosphorus slag and any leachate that it might generate is based on data from four sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); (2) industry responses to a RCRA §3007 request in 1989; (3) sampling and analysis conducted by EPA's Office of Research and Development (ORD) in 1984; and (4) literature addressing the radiological properties and hazards of elemental phosphorus slag. These data provide information on the concentrations of 20 metals, 8 radionuclides, gross alpha and beta radiation, and a number of other inorganic constituents (e.g., phosphate, phosphorus, fluoride, chloride, sulfate, ammonia, and nitrate) in total and leach test analyses. Three of the five elemental phosphorus facilities are represented by these data: Rhone-Poulenc/Stauffer's facilities in Mt. Pleasant, Tennessee and in Silver Bow, Montana, and the FMC Corporation plant in Pocatello, Idaho.

Concentrations in total sample analyses of the slag are consistent for most constituents across all data sources and facilities. However, cadmium concentrations for the FMC facility in Pocatello are more than an order of magnitude higher than in any other analyses. Constituent concentrations obtained from leach test analyses of the slag are also generally consistent across the data sources, types of leach tests (i.e., EP, SPLP, and TCLP), and facilities.

Process for Identifying Constituents of Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if elemental phosphorus slag or its leachate contain any chemical or radiological constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to screening criteria and then by evaluating the environmental persistence and mobility of any constituents that are present in concentrations that exceed the screening criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which elemental phosphorus slag constituents are released to the environment and migrate to possible exposure points. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the slag in greater detail.

Identified Constituents of Concern

Exhibits 7-3 and 7-4 present the results of the comparisons for elemental phosphorus slag total analyses and leach test analyses, respectively, to the screening criteria described above. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Of the 31 constituents analyzed in elemental phosphorus slag solids, only arsenic, cadmium, chromium, radium-226, and uranium-238 concentrations exceed a screening criterion (see Exhibit 7-3). All

Exhibit 7-3
Potential Constituents of Concern in Elemental Phosphorus Slag Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Chromium	4 / 5	Inhalation*	4 / 5	2 / 2
Arsenic	3 / 5	Ingestion*	3 / 5	2 / 2
Radium-226	6 / 6	Radiation*(c)	4 / 6	2 / 3
Uranium-238	1 / 1	Inhalation* Radiation*(c)	1 / 1 1 / 1	1 / 1 1 / 1
Cadmium	3 / 5	Inhalation*	1 / 5	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion, inhalation, or all radiation pathways. Human health effects from ingestion and inhalation include both cancer risk and noncancer endpoints. Ingestion or inhalation screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects. 'Radiation' entries are based on cancer risks from all radiation pathways.

(c) Includes direct radiation from contaminated land and inhalation of radon decay products.

of these constituents are metals or other inorganics that do not degrade in the environment. Chromium and radium-226 were detected in most of the samples analyzed (80 to 100 percent), and their concentrations in most analyses (approximately 70 to 80 percent) exceeded the screening criteria. Only cadmium and chromium were detected in concentrations that exceed the screening criteria by more than a factor of 10, however.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Chromium, cadmium, and uranium-238 concentrations in the slag may pose a cancer risk of greater than $1x10^{-5}$ if dust from the slag piles is blown into the air in a concentration that equals the National Ambient Air Quality Standard for particulates and then is inhaled by nearby individuals.

- Arsenic concentrations in the slag could pose a cancer risk of more than $1x10^{-5}$ if the slag is incidentally ingested on a routine basis (which could occur if access to closed piles is not restricted or if the slag is used off-site in an unrestricted manner that could allow people to come into direct contact with slag).

- The concentrations of uranium-238, radium-226, and other members of the uranium-238 decay chain could pose a radiation hazard if the slag is allowed to be used in an unrestricted manner. For example, as discussed in more detail in the next section, direct radiation doses and doses from the inhalation of radon could be unacceptably high if the slag is used in construction material or if people were allowed to build homes on top of the slag.

Exhibit 7-4
Potential Constituents of Concern in Elemental Phosphorus Slag Leachate[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Phosphorus	3 / 3	Aquatic Ecological	3 / 3	2 / 2
Fluoride	3 / 3	Human Health Resource Damage	3 / 3 2 / 3	2 / 2 2 / 2
Arsenic	4 / 6	Human Health*	4 / 6	2 / 2
Manganese	4 / 5	Resource Damage	3 / 5	2 / 2
Aluminum	4 / 5	Aquatic Ecological	3 / 5	2 / 2
Phosphate	3 / 3	Aquatic Ecological	2 / 3	1 / 2
Chromium	1 / 6	Resource Damage	1 / 6	1 / 2
Zinc	3 / 5	Aquatic Ecological	1 / 5	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a $1x10^{-6}$ lifetime cancer risk; others are based on noncancer effects.

Based on a comparison of EP leach test concentrations of 29 constituents to the surface and ground-water pathway screening criteria (see Exhibit 7-4), only 8 constituents (i.e., arsenic, aluminum, chromium, manganese, fluoride, phosphorus, phosphate, and zinc) exceed the water-based criteria. All of these constituents are also metals or other inorganics that do not degrade in the environment. Chromium and zinc appear to be of less concern because they were detected less frequently in the samples analyzed (less than 60 percent of the samples), and their concentrations exceeded the screening criteria in less than 20 percent of the samples. Only manganese and phosphorus were measured in concentrations that exceed the screening criteria by more than a factor of 10. Despite these exceedances of the screening criteria, however, none of the samples contained any constituents in excess of the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- If slag leachate is released to ground water and diluted by a factor of 10 or less during migration to a downgradient drinking water well, arsenic and fluoride concentrations could pose a health risk if ingested on a long-term basis without treatment. The diluted arsenic concentration could cause a cancer risk greater than $1x10^{-5}$.
- Concentrations of aluminum, phosphorus, phosphate, and zinc in slag leachate exceed the aquatic ecological screening criteria, suggesting that these contaminants could present a threat to aquatic ecological receptors if the leachate migrates (with 100-fol dilution or less) to surface waters.

- If slag leachate is released to ground water and diluted by a factor of 10 or less, the resulting concentrations of chromium, manganese, and fluoride could exceed the drinking water maximum contaminant level, potentially restricting future use of the ground water as a resource.

Although radionuclides in the slag solids appear to present a potential hazard, no radionuclides were detected at levels of concern in the slag leachate. Both radium-226 and gross beta contamination were analyzed in EP leach tests of the slag. The measured radium-226 concentrations ranged from 0.5 to 1.6 pCi/l, well below the maximum contaminant level of 5 pCi/l in drinking water. The measured gross beta concentrations ranged from 37 to 140 pCi/l, with an average of 83 pCi/l. While these values exceed the gross beta concentration recommended for drinking water,[8] 50 pCi/l, it is likely that the leachate concentration would be diluted by more than a factor of three if released to ground water. Therefore, any gross beta contamination in ground water caused by the release of the slag leachate is expected to be below the 50 pCi/l guideline.

These exceedances of the screening criteria, by themselves, do not demonstrate that the slag poses a significant risk, but rather indicate that the slag may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the slag to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the waste.

Release, Transport, and Exposure Potential

This analysis considers the potential for direct radiation exposures associated with the off-site use of elemental phosphorus slag, as well as potential releases and exposures through the ground-water, surface water, and air pathways as the slag was generated and managed at the five elemental phosphorus production plants in 1988. For this analysis, the Agency did not assess risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on which to base projections of future conditions.

Direct Radiation Exposure Potential

As discussed in Section 7.5, elemental phosphorus slag has been widely used for many years for a variety of purposes. For example, in the Idaho and Montana area, the slag has been used as an aggregate in concrete and asphalt, railroad ballast, roadbed fill, and farm road gravel. It has also been used in the construction of homes, buildings, streets, sidewalks, parking lots, school playgrounds, and other structures.

Many of these uses can cause increased radiation exposure to people living or working near the slag-bearing materials. Exposure is principally from direct gamma radiation emitted from radionuclides contained in the slag, but there is also a possibility for radiation exposure through the inhalation of radon decay products that may accumulate in the indoor air of structures built over or with the slag. Inhalation of slag dust originating from road traffic is also a possible exposure pathway.[9]

A recent EPA study[10] provides estimates of the direct radiation exposures and risks caused by the off-site use of elemental phosphorus slag in Pocatello and Soda Springs, Idaho. Exposure to outdoor sources (e.g., slag used in street paving) was estimated to be the greatest contributor to radiation doses in Pocatello. Average gamma-ray doses in Pocatello caused by the slag were estimated to be 14 millirem/year, posing a lifetime fatal cancer risk of $4x10^{-4}$. Calculated maximum doses and risks in Pocatello were roughly a factor of 10 higher. In Soda Springs, exposure to direct radiation within the home, caused by the use of slag in home foundations, was determined to be the greatest contributor to radiation doses. Average gamma-ray doses in Soda Springs caused by the slag were estimated to be 52 millirem/year, posing a lifetime risk of fatal cancer of $1.4x10^{-3}$. Doses and cancer risks to the maximally exposed individual in Soda Springs were 205 millirem/year and $6x10^{-3}$, respectively. While these risk estimates are presented in the EPA study, the Agency notes that the actual risks in Pocatello and Soda Springs could be roughly a factor of two higher.[11] For comparison, EPA's environmental radiation standards in 40 CFR 190 require operations in the uranium fuel cycle (including nuclear reactor operations) to keep radiation doses to members of the general public to less than 25 millirem/year.

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[8] No maximum contaminant level for gross beta contamination has been established, but compliance with 40 CFR 141.16 may be assumed if gross beta concentrations are less than 50 pCi/l.

[9] Conference of Radiation Control Program Directors, 1981. Natural Radioactivity Contamination Problems, Report No. 2, Report of the Committee, August 1981, p. 28.

[10] Environmental Protection Agency Study, 1990. Idaho Radionuclide Study. Office of Research and Development, Las Vegas Facility, Las Vegas, NV, April 1990.

While the study in Pocatello and Soda Springs did not detect a radon problem caused by the elemental phosphorus slag, elevated concentrations of radon in indoor air caused by the slag have been detected in other areas of the country. For example, indoor radon measurements conducted in 1,771 homes located in Butte, Montana revealed that 243 homes (14 percent) had indoor radon daughter concentrations above 0.02 working level,[12] attributable to elemental phosphorus slag.[13] For comparison, EPA's cleanup standards in 40 CFR 192 for soils near inactive uranium mill tailings sites limit the concentration of indoor radon decay products to 0.02 working level.

Ground-Water Release, Transport, and Exposure Potential

EPA's waste characterization data discussed above indicate that a number of constituents may leach from the elemental phosphorus slag at concentrations above the screening criteria. Considering only those contaminants that are mobile in ground water (given the existing slag management practices and neutral pH conditions that are expected), elemental phosphorus slag stockpiles could release arsenic, chromium, fluoride, phosphorus, and phosphate at concentrations that exceed the screening criteria. Manganese, aluminum, and zinc in the slag leachate are expected to be relatively immobile in ground water and should not be readily transported if released. Factors that influence the potential for these contaminants to be released and cause impacts through the ground-water pathway are summarized in Exhibit 7-

None of the elemental phosphorus plants report the use of engineered controls (e.g., liners, leachate collection systems) to limit infiltration through the piles.[14] Consequently, EPA evaluated the hydrogeologic setting of the plants to determine the potential for ground-water contamination from infiltration of precipitation through the slag piles.

- Compared to the other elemental phosphorus plants, both the Mt. Pleasant and Columbia plants are located in areas with relatively high to moderate potential for contaminants to migrate into ground water (i.e., net recharge is relatively high [25 cm/yr], but the aquifer is moderately deep [15 m]); both are in central Tennessee. Although drinking water wells could exist at private residences located 700 and 200 meters downgradient of the Mt. Pleasant and Columbia plants, respectively, the concentration of any released contaminants at these potential exposure points is likely to be below levels of concern (considering the generally low concentrations measured in the leachate).

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[11] In December 1989, the National Research Council published its Biological Effects of Ionizing Radiation or BEIR 5 Report that offers new risk estimates from radiation exposure. These new risk factors are about twice the risk factors used in the Pocatello and Soda Springs study.

[12] A "working level" is any combination of short-lived radon decay products in one liter of air that will result in the emission of alpha particles with a total energy of 130 billion electron-volts.

[13] Environmental Protection Agency, 1983. Evaluation of Radon Sources and Phosphate Slag in Butte, Montana. EPA 520/6-83-026, Washington, DC, June, 1983.

[14] The Silver Bow and Columbia plants did not provide data on their stockpiles. In the absence of better data, EPA has assumed that the piles at these facilities are not equipped with ground-water release controls.

Exhibit 7-5
Summary of Release, Transport, and Exposure Potential for Elemental Phosphorus Slag

Facility	Release, Transport, and Exposure Potential for Elemental Phosphorus Slag	Proximity to Sensitive Environments
SILVER BOW	Ground Water: Low net recharge (2.5 cm/yr) and large depth to aquifer (27 m) restrict ground-water contamination potential; potential drinking water exposure at residences within 800 m downgradient. Surface Water: Releases limited by low annual precipitation (34 cm/yr), gentle topographic slope (< 2%), and large distance (520m) to nearest stream; no known uses of stream, but its small size (5.2 mgd) indicates little assimilation capacity and, therefore, possible resource damage and aquatic ecological risks. Air: Insufficient data on pile size and dust suppression practices to support conclusion on release potential (although, facility monitoring of air quality has not detected any exceedance of air quality standards); average wind speeds up to 5.1 m/s and moderate number of wet days (78 days/year) could lead to airborne dust; potential exposures at residences as close as 840 m from the facility; population within 1, 5, and 50 miles of the facility is 79; 608; and 73,154, respectively.	No sensitive environments within 1.6 km
SODA SPRINGS	Ground Water: Releases from the slag pile may be limited by in-situ clay beneath the pile, low net recharge (5 cm/yr), and large depth to usable aquifer (27 m), but ground-water contamination that may be attributable to slag management has occurred at the site; potential drinking water exposures could occur at residences located only 60 m downgradient of the facility. Surface Water: Releases limited by stormwater runon/runoff controls and low annual precipitation (35 cm/yr); a river (420 mgd) is located 340 m from the facility, but it is not a source of drinking water near the facility, although it does provide irrigation water 270 m downstream of the facility. Air: Dust suppression used, but resident complaints indicate it may not be effective; average wind speeds up to 3.5 m/s and moderate number of wet days may (74 days/year) limit airborne dust; potential inhalation exposures at residences located adjacent to the facility boundary, and food chain exposures through deposition of particulate matter on agricultural fields in the vicinity of the facility; population within 1, 5, and 50 miles of the facility is 369; 4,560; and 100,596, respectively.	Wetland within 1.6 km

Exhibit 7-5 (cont'd)
Summary of Release, Transport, and Exposure Potential for Elemental Phosphorus Slag

Facility	Release, Transport, and Exposure Potential for Elemental Phosphorus Slag	Proximity to Sensitive Environments
POCATELLO	Ground Water: Ground-water monitoring indicates contamination possibly attributable to slag management; pile is unlined, but leaching of slag contaminants to useable ground water may be limited by low net recharge (1.2 cm/yr), great depth to aquifer (61 m), and presence of an intermediate, perched water table above the useable aquifer; potential drinking water exposures at residences located 300 m downgradient of the facility. Surface Water: Releases limited by the large distance to the Portneuf River (1400 m) and low annual precipitation (29 cm/yr); the nearest stream (with a flow of 160 mgd) is used for fish hatching 2.4 km downstream from the facility. Air: Potential releases are not controlled by dust suppression but the number of wet days that could suppress dust is moderately high (91 days/year); average wind speeds up to 6 m/s could lead to wind blown dust, and air quality monitoring at the facility has indicated past exceedance of the air quality standard for respirable particulate matter; potential inhalation exposures at residences as close as 240 m from the facility, and food chain exposures through deposition of particulate matter on agricultural fields in the vicinity of the facility; population within 1 mile is sparse (31 people) but population within 5 and 50 miles is 35,869 and 166,100 respectively.	No sensitive environments within 1.6 km
MT. PLEASANT	Ground Water: Pile underlain by in-situ clay, but high net recharge (25 cm/yr) and moderately deep aquifer (15 m) indicate high to moderate potential for release; potential drinking water exposures at residence located 700 m downgradient from facility. Surface Water: Although stormwater runon/runoff controls are employed, release potential is high because of high annual precipitation (130 cm/yr), moderate topographic slope (up to 6 percent), and short distance (120 m) to a nearby stream; no known uses of the stream (which has a flow of 1.5 mgd), but its small size indicates potential resource damage and ecological impacts resulting from small assimilation capacity. Air: Potential releases are not controlled by dust suppression, but may be limited by the relatively small size of the piles (3 to 9 acres) and the large number of wet days per year (106); average wind speeds up to 4.6 m/s could, nevertheless, lead to windblown dust; potential inhalation exposures at residences as close as 700 m from the facility; population within 1, 50, and 50 miles is 145; 8,435; and 479,893, respectively.	No sensitive environments within 1.6 km

Exhibit 7-5 (cont'd)
Summary of Release, Transport, and Exposure Potential for Elemental Phosphorus Slag

Facility	Release, Transport, and Exposure Potential for Elemental Phosphorus Slag	Proximity to Sensitive Environments
COLUMBIA	Ground Water: No data on management controls at the pile, but potential releases indicated by high net recharge (25 cm/yr) and moderately deep aquifer (15 m below land surface); potential drinking water exposures at residence located 210 m downgradient of the facility. Surface Water: No data on management controls at the pile, but potential releases indicated by high amount of annual precipitation (130 cm/yr), short distance to a nearby river (110 m), and moderate topographic slope (up to 6%); potential drinking water exposure from a public water supply intake located 12 km downstream. Air: No data on management controls at the pile, but releases may be limited by the large number of wet days per year (105); average wind speeds up to 4.6 m/s could, nevertheless, lead to wind blown dust; high inhalation exposure potential at a residence located 60 m from the facility, and potential food chain exposures through deposition of particulate matter on agricultural fields in the vicinity of the facility; population within 1, 5, and 50 miles is 418; 40,312; and 935,013, respectively.	Located in area of karst terrain; no other sensitive environments within 1.6 km

- The potential for ground-water contamination caused by the elemental phosphorus slag stockpiled at the Soda Springs (ID) plant appears to be relatively low based on the low net recharge (5 cm/yr) and the large depth to the aquifer (24 m). However, if contaminants reach the aquifer beneath this plant, they may pose human health risks (via drinking water) at a residence located less than 100 meters downgradient.
- The potential for slag at the Pocatello and Silver Bow plants to cause ground-water contamination appears lower because of even smaller net recharge (1.2 to 2.5 cm/year) and larger depths to useable aquifers (27 to 61 meters). Releases to the useable aquifer beneath the Pocatello plant are further limited by the presence of an intermediate, perched aquifer above the useable aquifer. If releases were to occur, exposures at these facilities may occur 300 meters downgradient of the Pocatello plant and 880 meters from the Silver Bow plant. Given the generally low concentrations of contaminants measured in the slag leachate, however, the concentrations at these distance exposure points are likely to be below levels of concern.

Ground-water monitoring results from Soda Springs, Pocatello, and Silver Bow show that releases to ground water have occurred although the extent to which the slag piles have contributed to this contamination is still under investigation. These facilities report that drinking water standards for fluoride, chloride, manganese, sulfate, cadmium, and selenium have been exceeded in downgradient monitoring wells. Except for chloride and selenium, these constituents have been detected in leach test analyses of elemental phosphorus slag. Therefore, although the facilities state that ground-water contamination cannot definitely be attributed to the stockpiles,[15] EPA's waste characterization data suggest that the slag piles may have contributed to observed ground-water contamination at these facilities.

Surface Water Release, Transport, and Exposure Potential

Constituents of potential concern in elemental phosphorus slag could, in theory, enter surface waters by migration of slag leachate through ground water that discharges to surface water, or by direct overland (storm water) run-off of dissolved or suspended slag materials. As discussed above, the following constituents leach from the slag at levels that exceed the screening criteria: arsenic, chromium, manganese, aluminum, fluoride, phosphorus, and phosphate. Other constituents present in the slag, such as cadmium, could also present surface water threats if slag particles reach surface waters.

The potential for overland release of slag particles to surface waters is limited considerably by the generally large size of the slag fragments. A small fraction of the slag material, however, may consist of fragments that are small enough to be erodible (i.e., approximately 0.01 cm in diameter or smaller). Because the stockpiles have relatively steep slopes (from 13 to 27 percent), erosion from the piles could lead to the overland flow of small slag particles or dissolved slag contaminants to nearby surface waters. At the Mt. Pleasant and Soda Springs plants, however, potential storm water run-off from the piles would be limited by the run-off controls reported by these two facilities.

Three of the four elemental phosphorus facilities providing data report that they monitor water quality in streams in the vicinity of the plant. Pocatello and Soda Springs report that ambient surface water concentrations downstream of their plants have exceeded drinking water standards or ambient water quality criteria (AWQC). Constituents detected in exceedance of standards or criteria include sulfate, cadmium, chloride, selenium, and manganese. All of these constituents have been detected in the slag. Therefore, the slag stockpiles cannot be ruled out as a possible source of this contamination based on EPA's waste characterization data, although site-specific factors (discussed below) indicate that the slag piles are likely to be only minor contributors to the contamination.

EPA's assessment of the potential for surface water releases and exposures at each facility depends on the use of controls to limit storm water run-off, hydrologic characteristics of the plant locations, the proximity of the plants to nearby streams, and the uses of these streams.

- The Columbia plant has moderate potential for releases of overland flow and ground-water seepage to surface water because it receives a relatively large amount of precipitation (i.e., 130 cm/year), which can transport contaminants by recharge to ground water or overland flow, and is located only 110 meters from Rutherford Creek.[16] However, the surface water damage potential is low, and not moderate or high, because the nearby creek has a large capacity to assimilate contaminant inflows (i.e., its annual average flow is 680 mgd).
- The Mt. Pleasant plant also has a moderate surface water release potential. Although this plant is located 120 meters from a small stream (Big Bigby Creek) with a flow of 1.5 mgd, overland releases of storm water run-off from its slag pile would be limited by run-off controls. As discussed above, this facility has a relatively high ground-water release potential. Therefore, seepage of contaminated ground water from the pile to the nearby stream may present aquatic ecological risks in the stream and/or restrict uses of this surface water resource (if it is large enough to be used). No health risks to existing human populations are expected because there are no intakes for drinking water supplies within 24 km (15 miles) of the plant.

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[15] For example, Monsanto attributes ground-water contamination at the Soda Springs facility to the pre-1984 use of unlined ponds for managing process wastewater. Refer to the case study findings later in this section for a discussion of the ground-water contamination at the Pocatello plant.

[16] Occidental did not provide information on the use of run-on/run-off controls at the slag pile, therefore, EPA assumes that releases from this unit are not limited by engineered controls.

- Slag piles at the western plants (Silver Bow, Pocatello, and Soda Springs) have relatively low surface water contamination potential because of large distances to nearby surface waters (i.e., 340 to 1,400 meters), low levels of precipitation (i.e., 29 to 35 cm/year), and relatively low ground-water release potential. The release potential at the Soda Springs plant is further limited by storm water run-off controls employed at the slag pile. If releases to these surface waters did occur, the potential for resource damage and aquatic ecological risks is greatest at the Silver Bow plant because the Silver Bow Creek has a small assimilative capacity (less than 5.2 mgd). If releases from the Pocatello plant reach the Portneuf River and are not sufficiently diluted, they could endanger aquatic life in the river, harm current use of the river as a fish hatchery, and restrict potential future uses of the river. Releases from slag piles at the Soda Springs plant could jeopardize consumptive uses of Little Spring Creek and Bear River (such as the current use for irrigation) and endanger the streams' aquatic life, if contaminants are not sufficiently diluted by the water's flow.

In summary, although surface water releases may be somewhat limited by the physical form of the slag and the use of storm water run-off controls at two facilities (Mt. Pleasant and Soda Springs), surface water releases of slag contaminants may occur by the seepage of leachate to ground water that discharges to surface water or by the overland flow of small fragments of slag. At the two facilities located in Tennessee (Mt. Pleasant and Columbia), surface water releases are more likely than at the facilities in Idaho and Montana (Pocatello, Soda Springs, and Silver Bow) because of the greater amount of precipitation (which leads to overland flow and ground-water discharge) and their close proximity to streams. Only slag at the Columbia plant poses a potential human health threat via the surface water pathway at present, and even this threat is very minor considering the large assimilative capacity of Rutherford Creek. The other facilities conceivably may pose aquatic ecological threats and/or restrict current and potential future uses of the streams, if contaminants entering these waters are not sufficiently diluted.

Air Release, Transport, and Exposure Potential

Because all of the constituents of concern in elemental phosphorus slag are nonvolatile, slag contaminants can be released to air only in the form of dust particles. As discussed above, uranium-238, cadmium, and chromium are present in the slag in concentrations that exceed the inhalation screening criteria. EPA's Office of Air and Radiation recently promulgated regulations governing the airborne emissions of radionuclides from elemental phosphorus plants (54 FR 51654, December 15, 1989). However, these standards apply only to airborne releases of radionuclides from calciners and nodulizing kilns, not to slag management units or operations.

Factors that affect the potential for airborne releases -- by either wind erosion or vehicular traffic disturbance -- include the particle size and moisture content of the slag, the area of the stockpiles, wind speeds, and the use of dust suppression methods.

Release of elemental phosphorus slag particles to the air is limited in part by the large particle size and glassy form of the slag. In general, particles that are $\leq$ 100 micrometers (μm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 μm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 μm in diameter are respirable. The slag generally consists of particles larger than 100 μm in diameter (i.e., the maximum particle size that is suspendable and transportable), and therefore, the majority of the slag is not suspendable, transportable, or respirable. It is likely that only a small fraction of the slag will be weathered and aged into smaller particles that can be suspended in air, and after the small, near-surface particles are depleted, airborne emissions would be expected to decline to low levels. Nevertheless, considering the large exposed surface area of the slag stockpiles and concerns about dusting that have been expressed by EPA Regional personnel and local residents, the Agency acknowledges that large quantities of dust from elemental phosporous slag piles may be blown into the air during high winds.

Other, site-specific factors that influence the potential for dusting and subsequent exposures are described below:

- Potential dust releases from the Columbia plant may be limited by the large number (105 days/year) of days with precipitation. However, this plant has a relatively high air pathway exposure potential because the nearest residence is located only 46 meters away from the plant, and the population in the vicinity of the facility is relatively dense (i.e., population within 1.6, 8, and 80 km (1, 5, and 50 miles) is 418; 40,312; and 935,013 people, respectively).

- At the Pocatello plant, high dust suspension potential is indicated by past exceedances of the air quality standard for respirable particulate matter and high wind speeds (an average of up to 6 m/s). The source of this dust is not specified in the available data. The number of days with precipitation that could suppress dust is moderate (91 days/year). Air pathway exposures could occur at residences located 240 meters from this plant. The population within 1.6 km (one mile) of the facility is relatively sparse (31 people), but the population within 8 and 80 km (5 and 50 miles) is 35,900 and 166,100 people, respectively.

- Although dust suppression is practiced to control airborne releases from the Soda Springs slag pile, complaints about windblown dust from the stack indicate that this control may not be effective. Potential exposures could occur at a residence located directly adjacent to the facility boundary near the stack, and the population within 1.6, 8, and 80 km (1, 5, and 50 miles) of the facility is relatively dense (i.e., 369; 4,600; and 100,600 people, respectively).

- Silver Bow and Mt. Pleasant have relatively low air pathway release and exposure potential because of more moderate typical winds and the greater distance to nearby residences (640 to 805 meters). The potential for release may be comparatively greater at the Silver Bow facility because of the smaller number of days with precipitation that could suppress dust (78 days/year), and the higher average wind speeds (5.1 m/s). The potential for exposure, on the other hand, is greater at the Mt. Pleasant facility because of the dense population around the facility (population within 1.6, 8, and 80 km (1, 5, and 50 miles) is 145; 8,400; and 479,900 people, respectively).

Three of the facilities -- Soda Springs, Pocatello, and Columbia -- are located in areas with significant agricultural land use. In addition to potential inhalation risks, airborne releases of slag contaminants at these facilities could enter the human food chain through the deposition of suspended slag particles onto crops. Based on these findings, EPA acknowledges the need for further study and possible control of windblown dust from elemental phosphorus slag piles, especially at the Soda Springs, Pocatello, and Columbia facilities, both during the operating life of the piles and after closure.

Proximity to Sensitive Environments

As summarized in Exhibit 7-5, only the Soda Springs and Columbia plants are located in environments that are vulnerable to contaminant releases or environments with high resource value that may warrant special consideration.

- The Soda Springs facility is located within one mile of a wetland area (defined here to include swamps, marshes, bogs, and other similar areas). Wetlands are commonly entitled to special protection because they provide habitat for many forms of wildlife, purify natural waters, provide flood and storm damage protection, and afford a number of other benefits. Although the potential for ground-water and surface water releases from the slag pile at this facility is low, any such releases could adversely affect the function and value of this wetland area.

- The Columbia facility is located in an area of karst terrain (i.e., irregular topography characterized by solution features in soluble rock such as limestone). Releases to ground water in karst terrain can pose ground-water and surface water health risks and ecological risks because of the limited dilution potential of the conduit flow that is characteristic of ground-water movement in such areas (i.e., solution cavities that may exist in the bedrock at this site could permit any ground-water contamination originating from the slag pile to migrate in a largely unattenuated and undiluted fashion).

Risk Modeling

Based upon the evaluation of intrinsic hazard, the descriptive analysis of factors that influence risk presented above, and upon a comprehensive review of information on documented damage cases (presented in the next section), EPA has concluded that the ground-water and surface water risks posed by elemental phosphorus furnace slag are relatively low when the slag is managed on-site according to current practice. However, windblown dust at three facilities may pose a moderate risk via the inhalation and ingestion pathways. This overall conclusion is supported by the generally low to moderate risk estimates predicted by the Agency's modeling of other mineral processing wastes that appear to pose a substantially greater risk when managed in on-site stockpiles. Therefore, the Agency has not conducted a quantitative risk modeling exercise to examine the hazards of on-site slag management in greater detail. The Agency recognizes that the radiation risks associated with the off-site use of elemental phosphorus slag are high. EPA did not attempt to model these risks, however, because the recently completed study in Pocatello and Soda Springs provides definitive risk estimates based on actual field observations.

7.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the environmental performance of slag waste management practices at the five elemental phosphorus facilities. The file review process was combined with interviews with state and EPA regional regulatory staff to develop a complete and accurate assessment of the extent to which slag has resulted in cases of documented danger to human health or the environment.

These sources did not reveal any sites with documented environmental damage that was clearly the result of management practices at units containing elemental phosphorus slag. However, concentrations of some heavy metals in ground water in excess of primary drinking water standards were documented, along with abandonment of an off-site drinking water well due to heavy metal contamination at the FMC facility in Pocatello.[17] The information reviewed indicates that unlined waste ponds appeared to be the source of the contamination at this facility. These unlined ponds, which have been replaced by lined ponds, contained a variety of wastewaters, including "phossy water, precipitator dust slurry, calciner scrubber water, slag cooling water, and general site run-off." None of these waste management units are known to contain slag; however, the slag cooling water pond, and possibly the "rainwater pond" as well, are related to slag management. Sampling of the ponds during a Superfund Site Investigation indicated that concentrations of some constituents in the slag cooling water pond were more than 100 times the primary drinking water standard.[18,19]

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[17] Ground-water contamination in the area of the facility and the adjacent J. R. Simplot phosphoric acid plant has led to the area being proposed for the Superfund National Priority List (see Eastern Michaud Flats Contamination).

[18] Ecology & Environment, 1988. Site Inspection Report for FMC/Simplot, Pocatello, Idaho. TDD F10-8702-09110. April, 1988.

[19] Ecology & Environment, 1988. Special Study Waste Analysis for Eastern Michaud Flats Groundwater Contamination. November, 1988.

7.3.3 Findings Concerning the Hazards of Elemental Phosphorus Slag

Based upon the detailed examination of the intrinsic hazards of elemental phosphorus slag, the management practices that are applied to this waste, the environmental settings in which the generators of the material are situated, and the documented environmental damages that have been described above, EPA concludes that these wastes pose a low to moderate risk to human health and the environment as currently managed on-site, but a high risk when used off-site in construction due to the radioactivity of the material.

Available data on the composition of elemental phosphorus slag show that the slag contains nine nonradioactive contaminants in concentrations that exceed the risk screening criteria, although only four constituents exceed the criteria by more than a factor of 10. In addition, the slag contains elevated concentrations of uranium-238 and its decay products that may pose a significant radiation hazard if the slag is not properly controlled. Based on available sampling data and professional judgment, however, EPA does not believe that the slag exhibits any of the characteristics of hazardous waste (ignitability, corrosivity, reactivity, or EP toxicity).

Elemental phosphorus slag has been widely used for many years for a variety of purposes, many of which can cause increased radiation exposure to people living or working near the slag-bearing materials. Recently completed EPA research shows that significant cancer risks have been caused by the off-site use of elemental phosphorus slag in street paving and home foundations in Soda Springs and Pocatello, ID. According to these research findings, average lifetime cancer risks caused by exposures to direct gamma radiation from these materials range from $4x10^{-4}$ in Pocatello to $1x10^{-3}$ in Soda Springs; lifetime cancer risks of maximally exposed individuals in these two cities can be as high as $6x10^{-3}$. EPA notes, however, that the cancer risks in these two cities may actually be a factor of two higher. Because of these high risks, the State of Idaho banned the use of elemental phosphorus slag in all occupied structures in 1977, but slag can still be used as an aggregate in road construction in Idaho. Any future uses of elemental phosphorus slag in Idaho and elsewhere need to be closely evaluated and controlled to prevent high radiation exposures.

Based on a review of existing management practices and release exposure conditions, EPA believes that the current practices of managing the slag at the five active elemental phosphorus facilities generally pose a low risk via the ground-water and surface water exposure pathways. Although low levels of ground-water recharge and large depths to ground water at three of the facilities appear to limit the potential for slag contaminants to migrate into ground water, contamination that may be attributable to the slag has been observed. At the other two facilities, releases of constituents are not controlled by favorable hydrogeologic conditions, so migration of contaminants into ground water is possible. This migration, however, is not expected to pose significant current risks at any of the sites because of the relatively low concentrations of potentially harmful constituents in laboratory leachate of the slag. The generally large size of slag particles limits the potential for water erosion to transport slag contaminants to surface water exposure points. Surface water contamination potential is also limited by the relatively large distances from three of the facilities to the nearest surface waters. The absence of documented cases of ground-water and surface water damage that clearly results from elemental phosphorus slag management further supports the finding that this waste, when managed on-site, poses a relatively low ground-water and surface water risk.

However, EPA believes that current slag management at three facilities poses a moderate risk via the air exposure pathway. Although the generally large size of slag particles tends to limit wind erosion, large quantities of dust blowing from the slag pile at one facility has been alleged by nearby residents and the slag pile at another facility is recognized as a potential contributor to high levels of airborne particulates. Exposures of nearby residents to any windblown contaminants at these two and one other facility are possible, and EPA acknowledges the need for further study and possible control of windblown dust at these sites. Air pathway exposures at the other two facilities are, at present, less likely because of the large distance to potential receptors.

7.4 Existing Federal and State Waste Management Controls

7.4.1 Federal Regulation

The Stauffer Chemical Company facility in Silver Bow, Montana, which generates elemental phosphorus slag, is located on Federal land (in a National forest), and is therefore subject to the regulations set forth by the U.S. Department of Agriculture's Forest Service. The regulations governing the use of the surface of National Forest Service lands (36 CFR 228 Subpart A) are intended to "minimize adverse environmental impacts...." They require that operators file a "notice of intent to operate." If deemed necessary, the operator may be required to submit a proposed plan of operations in order to ensure minimal adverse environmental impact.

Section 3001(b)(3)(iii) of RCRA, which was added by the Solid Waste Disposal Act Amendments of 1980 (Oct. 21, 1980), provides EPA with the authority to develop regulations "to prevent radiation exposure which presents an unreasonable risk to human health from the use in construction or land reclamation (with or without revegetation) of (I) solid waste from the extraction, beneficiation, and processing of phosphate rock or (II) overburden from the mining of uranium ore."

The National Environmental Policy Act (NEPA) may also be applicable to this facility. NEPA may require that an Environmental Impact Statement (EIS), which establishes the framework by which EPA and the Council on Environmental Quality may impose environmental protection requirements (40 CFR Parts 1500-1508), be prepared for any ore processing activities on Federal lands.

EPA is unaware of any other specific management control or pollutant release requirements that apply specifically to elemental phosphorus slag (the October, 1989 National Emissions Standard for Hazardous Air Pollutants (NESHAP) controlling radionuclide emissions from elemental phosphorus plants only addresses stack emissions, not slag or other potential radionuclide sources (54 FR [illegible]671)).

In the State of Idaho, which has no EPA-approved NPDES program, EPA would utilize State water quality standards when writing NPDES permits.

7.4.2 State Regulation

The five facilities generating elemental phosphorus furnace slag are located in three states, Idaho, Tennessee, and Montana. Two facilities are located in both Idaho and Tennessee, while a single facility is located in Montana. All three states were selected for regulatory review for the purposes of this report (see Chapter 2 for a discussion of the methodology used to select states for detailed regulatory study).

All three states with elemental phosphorus facilities exclude mineral processing wastes, including the furnace slag generated at these facilities, from hazardous waste regulation. Of the three states, only Tennessee has solid waste regulatory provisions that apply to elemental phosphorus furnace slag. Tennessee's solid waste regulations include provisions for industrial solid waste landfills, which include landfills used to dispose of furnace slag. The state's implementation of its solid waste regulations, however, has focused on municipal solid waste landfills; the two elemental phosphorus facilities in Tennessee both have permits for on-site industrial landfills, but are not currently subject to strict design or operating criteria. Tennessee recently amended its regulations and appears to be preparing to regulate mineral processing wastes more comprehensively. Under the new regulations, the two elemental phosphorus facilities could be required to undertake various management practices, such as the submission of design drawings for approval, the preparation of contouring plans, the installation of liners and leachate collection systems, and conditional ground-water monitoring. The new regulations also include provisions for financial assurance for closure and 30 years of post-closure care.

In contrast to Tennessee's solid waste regulatory efforts, neither Idaho nor Montana currently regulates elemental phosphorus slag as solid waste. Idaho does not require solid waste permits for the disposal of mineral processing wastes, including elemental phosphorus furnace slag. Montana classifies mineral processing wastes as solid wastes, but does not regulate these wastes if they are disposed of on-site, as happens at the single Montana elemental phosphorus facility, and the wastes do not pose a nuisance or health hazard. Of all three states, only Idaho specifically prohibits the use of elemental phosphorus furnace slag in construction materials for habitable structures.

Water and air quality regulations vary in their applicability to mineral processing wastes across the three states, but generally follow the pattern set by current solid waste regulation. Tennessee's water quality regulations require that no sewage, industrial waste, or other wastes may cause a violation of state water quality standards. Both facilities in Tennessee maintain state-administered NPDES permits. Idaho's regulations make no mention specifically of mineral processing wastes but require all non-sewage discharges to be treated in order to comply with federal water quality standards. According to state officials in Montana, run-off from elemental phosphorus slag piles does not require a NPDES permit and is not addressed otherwise. Finally, although mineral processing facilities in all three states must obtain air permits in order to operate, there are no specific regulations addressing fugitive dust suppression for elemental phosphorus furnace slag in any of the three states.

In summary, all three states with elemental phosphorus facilities exclude from hazardous waste regulation the furnace slag generated at those facilities. Moreover, two of the states, Idaho and Montana, are effectively not requiring environmental controls for on-site disposal of these slags under their solid waste regulations. Tennessee's solid waste regulations do include provisions for industrial solid wastes. Although these regulations have not been implemented aggressively to date, the state recently revised its solid waste rules and appears to be preparing to regulate furnace slag and other mineral processing wastes more comprehensively. Tennessee and Idaho have water quality provisions that could apply to furnace slag waste management activities, though only the two facilities in Tennessee maintain NPDES permits for those activities. Montana does not require a NPDES permit for run-off discharges from its facility's furnace slag waste piles. Finally, none of the three states have fugitive dust suppression provisions for furnace slag disposal units in their air regulations.

7.5 Waste Management Alternatives and Potential Utilization

Waste Management Alternatives

By waste management alternatives, EPA is referring to both ways of actually disposing of the waste (e.g., landfills and waste piles), and methods of minimizing the amount of waste generated. Waste minimization generally encompasses any source reduction or recycling that results in either the reduction of total volume or toxicity of hazardous waste. Source reduction is a reduction of waste generation at the source, usually within a process. Source reduction can include process modifications, feedstock (raw material) substitution, housekeeping and management practices, and increases in efficiency of machinery and equipment. Source reduction includes any activity that reduces the amount of waste that exits a process. Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process.

Disposal Alternatives

Of the four facilities that did not designate the relevant portions of their 1989 SWMPF Surveys as confidential, none sends its slag off-site for disposal. While it is conceivable that some, or even all, of the facilities could do so, the cost of transporting large volumes of phosphorus slag, and the rising cost of commercial landfill capacity make it unlikely that elemental phosphorus processors will utilize off-site disposal capacity if on-site capacity is available and the regulatory status of the material does not change. Situations that could increase the likelihood of off-site disposal are the classification of elemental phosphorus slag as hazardous waste, a limited amount of area for on-site disposal, and reduced slag generation rates. Increased need for disposal in general (either on-site or off-site) would result from increased restrictions on uses of the slag.

Waste Minimization

Opportunities for waste minimization may include raw material substitutions, though these opportunities are somewhat limited because of the transportation costs involved in using ores or concentrates produced in other regions or countries. Consequently, raw materials substitution generally takes the form of improving the separation of the value from the raw ore during beneficiation, so that the furnace operations would begin with a higher grade of ore concentrate. Processing a feedstock with a higher concentration of phosphorus results in decreased slag generation, although presumably increasing the generation of related beneficiation wastes. Other source reduction opportunities may involve processing modifications to increase the efficiency of phosphorus recovery during the furnace operation.

Waste Utilization

Utilization of mineral processing "wastes" can be a viable alternative to disposal. In 1988, for example, Occidental's Columbia plant reported selling all of its slag, while three other facilities are known to have sold some portion of their slag for off-site use (specific data are confidential). Only the Silver Bow facility reported disposing all of its slag rather than selling it as a product. However, there may be risks associated with such practices, as indicated by the EPA studies in Idaho.

Option 1: Utilization as a Highway Construction Aggregate

Description. Phosphorus slag is used as an aggregate in asphalt manufacturing. It normally requires crushing and sizing by slag processing contractors to meet specific aggregate size requirements before it can be mixed with the asphalt.

Current and Potential Use. Elemental phosphorus slag has been used extensively in highway construction for many years in Idaho, Montana, and Tennessee.[20] Its hardness, uniformity, and inert chemical composition make it an excellent aggregate material for construction purposes and it is specified as a skid resistant coarse aggregate in bituminous wearing surfaces. The material is used in various phases of highway construction, including crushed base, crushed aggregate for asphalt (i.e., bituminous paving and seal coats), and as casting material for highway structures. The Occidental facility in Tennessee was able to sell nearly all of the slag it produced in 1988, a significant portion of which is believed to have been used for highway construction.[21] The facility indicated that they could sell even more of the material if more was produced. The demand for phosphorus slag is high in Tennessee because supplies of natural aggregate are sparse. As noted above, however, recent studies in Idaho indicate that such uses contribute significantly to gamma radiation exposure of the local populations.

Although the Stauffer Chemical Company in Montana reportedly sold none of the slag that it generated in 1988, phosphorus slag is known to have widespread usage in road construction in both Idaho and Montana.[22] Demand for the slag as an aggregate in Idaho and Montana is expected to be lower than the demand in Tennessee because of the locations of the facilities with respect to market areas and the problem of residual radioactivity in the western ores.

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[20] Collins, R.J. and R.H. Miller, Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis, FHWA-RD-76-106, prepared for Federal Highway Administration, May 1976, p. 168.

[21] Private communication with Eddie Floyd, Occidental Chemical Co., April 11, 1990.

[22] Collins, R.J. and R.H. Miller, op.cit.

The potential of phosphorus slag as a construction aggregate depends, at least partly, on its ability to successfully compete in the market place with the other sources of aggregates. The effect of facility location on its competitiveness in the market is discussed below, and competitive pricing is discussed in the section on feasibility.

Access to Markets. Because aggregate is a relatively low value, high bulk commodity, transportation costs are a key factor in establishing and maintaining markets for this product. Accordingly, producers must be located in relatively close proximity to product markets to be price competitive and, therefore, economically viable, or aggregate must be in short supply to justify haul distances greater than 80 to 160 km (50 to 100 miles).[23] The two facilities in Idaho are both located approximately 480 km from Salt Lake City, 320 km from Twin Falls, and less than 400 km from Pocatello. The two facilities are also located within 400 km of an area in central Montana that has an aggregate shortage. The Stauffer plant in Silver Bow, Montana is located within 16 km of Butte, within 160 km of Helena and Missoula, and less than 240 km from the area in central Montana with an aggregate shortage. The two facilities in Tennessee are both located within 160 km of Nashville, Huntsville, and Chattanooga, and within 160 km of an area in eastern Tennessee with an aggregate shortage. The Tennessee facilities are also located approximately 480 km from Memphis and an aggregate shortage area in western Tennessee. Therefore, all of the facilities have potential markets for their slag as an aggregate material.

Factors Relevant to Regulatory Status. The primary environmental concern for elemental phosphorus slag stems from the radionuclides found in the slag. The slag is typically composed of approximately 44 percent calcium, or lime (CaO), 44 percent silica (SiO_2), 6 percent alumina (Al_2O_3), 1 percent iron oxide (Fe_2O_3); it also contains most of the nonvolatile radionuclides originally present in the ore. Radium-226 levels in elemental phosphorus slags from Idaho and Montana have been observed to range from 4 to 32 pCi/g, whereas the concentrations in slag from the two facilities in Tennessee have been measured at 3.2 to 27 pCi/g.[24,25] Concentrations of uranium and thorium in elemental phosphorus slag range from 23 to 50 pCi/g in Montana and Idaho, and from 2.4 to 45 pCi/g in Tennessee.[26,27]

Due to concerns over radiation exposure, the State of Idaho has prohibited the use of phosphorus slag in the construction of habitable structures since 1977,[28] though slag is still used as an aggregate in road construction in Idaho. Exposure rates of 100 microroentgens per hour (μR/h) have been measured at outdoor slag piles at the FMC plant in Pocatello, Idaho,[29] as compared to natural background radiation in the same area of 9 μR/h.[30] In addition, significant gamma radiation exposures associated with a variety of slag construction uses have been identified (see discussion in Section 7.3.1).

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[23] Ibid, p. 239.

[24] Stula, R.T., et. al., Airborne Emission Control Technology for the Elemental Phosphorus Industry--Final Report to the Environmental Protection Agency, prepared for U.S. Environmental Protection Agency Under Contract Number 68-01-6429, January 26, 1984, pp. 3-38, 3-59, 3-75, 3-129, and 3-162. Data provided in this report for facilities that have been closed are not included in the discussion here.

[25] Company responses to EPA's National Survey; see footnote 2.

[26] Stula, et. al., op. cit., pp. 3-38, 3-59, 3-76, 3-129, and 3-162.

[27] Company responses to EPA's National Survey; see footnote 2.

[28] Baker, E.G., H.D. Freeman, and J.N. Hartley, Idaho Radionuclide Exposure Study--Literature Review, prepared for U.S. Environmental Protection Agency, Office of Radiation Programs, under a related services contract with the U.S. Department of Energy, Contract DE-AC06-76RLO 1830, October, 1987, p. 4,6

[29] Radiological Surveys of Idaho Phosphate Ore Processing - The Thermal Process Plant, prepared for the U.S. Environmental Protection Agency, Office of Radiation, Los Vegas Facility, November, 1977, pp. 8-9.

[30] Ibid.

While there are a number of constituents that can leach from elemental phosphorus slag, the entrainment of the slag within the asphalt matrix should significantly reduce the potential for leaching. In addition, the slag itself is a glass-like material containing the radionuclides in a vitrified matrix, which significantly limits leaching potential in the original material. However, if the asphalt were to exhibit any undesirable characteristics (e.g., significant leaching of radionuclides), the environmental impacts could be extensive because the slag would be widely distributed.

The slag particles that are too small to be used as aggregate require disposal, unless they can be utilized in some other way (e.g., as a substitute for portland cement, as is discussed later). If disposed, there is a greater potential for leaching, since the small particle size of the slag fines will cause them to have a greater surface area than the same quantity of unprocessed phosphorus slag.

Feasibility. The use of elemental phosphorus slag in highway construction is technically and economically feasible, as evidenced by its continued use for this purpose. EPA has not identified any existing regulatory constraints on the use of phosphorus slag in highway construction.

Future slag utilization as an aggregate will depend on the price of competing aggregate materials, the cost of retrieving and crushing and screening (i.e., sizing) the slag, the distance the slag must be transported to its point of use, regulatory limitations, and its social acceptability (i.e., concerns over radiation risks).

Other Options

There are a number of other potential ways to utilize phosphorus slag which are mentioned in the literature, but for which there is little information beyond the fact that an alternative use of the slag has been employed. In the following paragraphs, EPA discusses and comments on each alternative to the extent permitted by the available information.

Use in Making Portland Cement and Concrete. Phosphorus slag has been used as a substitute for portland cement rock in the manufacturing of portland cement.[31] In addition, the University of Tennessee has evaluated several sources of phosphorus slag for use as fine aggregates. As a result of this study, phosphorus slag produced by Monsanto at Columbia, Tennessee, were found to be acceptable (in terms of materials performance) for use in portland cement concrete.[32] The slag has been used as an aggregate for portland cement concrete in making constructions blocks, and pouring driveways, patios, and drainage ditches.[33] However, such uses have been prohibited in some areas and significant gamma radiation exposure from such uses has been documented (see Section 7.3.1).

Radionuclide emission testing of the use of phosphorus slag as a construction aggregate led to a 1977 ban by the State of Idaho on the use of the material in construction of habitable structures.[34] However, the radionuclide properties of phosphorus slag vary significantly by the location of the ore deposits. Therefore, the feasibility and acceptability of using phosphorus slag as an aggregate for portland cement concrete will also depend on the origin of the slag.

Raw Material for Making Ceramic Tile. Phosphorus slag was found to have a composition corresponding to a pseudo-wollastonite known as the alpha form of natural wollastonite, a mineral that is mined in large tonnages to supply the ceramic tile industry. Research has demonstrated that phosphorus slag would be suitable (in terms of materials performance) for use in production of high-quality tile products. When properly ground and treated magnetically to remove iron constituents (magnetite), the slag comprised a raw material suitable for forming, dry pressing, sintering, and glazing to yield high quality floor and wall tile. The estimated production cost compared favorably with the cost of commercially produced wall tile.

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[31] Kirk Othmer, Encyclopedia of Chemical Technology, Third Edition, Volume 5, Wiley-Interscience Publications, John Wiley and Sons, p. 187.

[32] Collins, R.J. and R.H. Miller, op.cit., p. 197.

[33] Stula, et. al., op. cit., pp. 3-4.

[34] Baker, Freeman, and Hartley, op. cit.

Railroad Ballast and General Construction Uses. Elemental phosphorus slag is currently used as railroad ballast and as stabilization material for stockyards.[35] In Florida, where the use of elemental phosphorus slag in habitable structures has not been prohibited, slag has been used on roofing shingles and in septic tank fields. It has also been used in the manufacturing of rockwool insulation.[36]

Using phosphorus slag as railroad ballast or in general construction use does not change the chemical or physical characteristics of the slag, although it may have some effect on the ability of the slag's potentially hazardous constituents to leach and contaminate ground and/or surface waters. The concentration of radium-226 in slag pile rainwater runoff at the Pocatello plant has been observed to be 0.70 pCi/g in the liquid fraction and 14 pCi/L in the suspended solids fraction. When the slag is used as railroad ballast, the surface area available for leaching may be increased, though the actual rate of leaching will depend on environmental settings, and could therefore vary considerably.

7.6 Cost and Economic Impacts

Because the available data indicated that elemental phosphorus slag does not exhibit any of the characteristics of hazardous waste, the issue of how waste management costs might change if Subtitle C regulatory requirements were applied and what impacts such costs might impose upon affected facilities is moot. Accordingly, EPA has not estimated costs associated with removing elemental phosphorus slag from the Mining Waste Exclusion, which EPA's data indicate would have no practical effect on waste management costs.

EPA does have significant concerns about certain off-site uses of elemental phosphorus slag because of the relatively high residual radioactivity contained within this material. EPA has not, however, calculated the costs or impacts associated with limiting or prohibiting sales of elemental phosphorus slag for particular off-site uses for this report.

7.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For the special waste generated by this commodity sector (elemental phosphorus slag), these categories address the following three major topics: (1) the potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of elemental phosphorus slag is moderate to high in comparison to the other mineral processing wastes studied in this report. The slag does not exhibit any of the four characteristics of hazardous waste and contains only four constituents that exceed one or more of the screening criteria used in this analysis by more than a factor 10. However, elemental phosphorus slag also contains elevated concentrations of uranium-238 and its decay products that may pose a significant radiation hazard if the slag is not properly controlled.

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[35] Baker, Freeman, and Hartley, op.cit., pp. 4-6.

[36] Stula, et. al., op.cit., pp. 3-4.

Based on a review of existing management practices and release/exposure conditions, EPA believes that the current on-site slag management practices at the five active elemental phosphorus facilities generally pose a low risk via the ground-water and surface water exposure pathways. Low levels of ground-water recharge and large depths to ground water at three of the facilities appear to limit the potential for slag to cause ground-water contamination, but contamination that may be attributable to the slag has been observed. At the other two facilities, releases of constituents are not controlled by favorable hydrogeologic conditions, so migration of contaminants into ground water is possible. This migration, however, is not expected to pose significant risks at any of the sites because of the relatively low concentrations of potentially harmful constituents in slag leachate, as determined by laboratory tests. The generally large size of slag particles limits the potential for stormwater erosion to transport slag contaminants to surface water exposure points. Surface water contamination potential is also limited by the relatively large distances from three of the facilities to the nearest surface waters. The absence of documented cases of ground-water and surface water damage that clearly results from elemental phosphorus slag disposal further supports the finding that on-site disposal of this waste poses a relatively low risk via these pathways. However, EPA believes that on-site slag management at three facilities poses a moderate risk via the air exposure pathway. Although the generally large size of slag particles also tends to limit wind erosion, dust from the slag piles may be blown into the air and lead to significant exposures of residents near three of the plants. No people live near the other two plants and significant exposures through the air pathway are not likely at these plants.

In contrast, EPA studies have shown that use of elemental phosphorus slag in residential building and municipal (e.g., road, sidewalk) construction applications has resulted in unacceptable human exposure to gamma radiation and resultant high incremental cancer risk. According to recent EPA research findings, average lifetime cancer risks caused by exposures to direct gamma radiation from elemental phosphorus slag used in street paving and home foundations in Soda Springs and Pocatello, ID range from $4x10^{-4}$ to $1x10^{-3}$; lifetime cancer risks of maximally exposed individuals in the two cities that were studied can be as high as $6x10^{-3}$.[37] EPA notes with interest that use of slag in inhabited structures has been prohibited in the State of Idaho for more than ten years, and believes that the radiation risks associated with the off-site use of elemental phosphorus slag should also be addressed on the national level.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The relatively low to moderate risk from the on-site management of elemental phosphorus slag is expected to continue in the future in the absence of Subtitle C regulation given current waste management practices and environmental conditions at the five active facilities. The characteristics of this waste are unlikely to change in the future, and although this analysis is limited to the five sites at which the waste is currently managed, EPA believes that it is unlikely, based on overall market conditions and the marginal profitability of the industry, that elemental phosphorus production will expand to other locations. Therefore, the Agency believes that the findings and conclusions of this study reflect conditions at all locations at which elemental phosphorus slag is expected to be managed on-site in the future.

In the absence of more stringent federal regulation of on-site management of elemental phosphorus slag, state regulation is expected to continue to control risks to a limited extent. Furnace slag from elemental phosphorus production is generated in three states, Tennessee, Montana, and Idaho, all of which exempt this waste from hazardous waste regulation. Of these three states, only Tennessee addresses furnace slag under its solid waste regulations. Tennessee, however, has historically focused its regulatory efforts on municipal solid waste problems; the two elemental phosphorus facilities in the state both have permits for on-site industrial landfills, but are not currently subject to strict design or operating criteria. Tennessee recently revised its regulations to address industrial solid wastes, including mineral processing wastes such as furnace slag, more stringently. Montana exempts furnace slag from its solid waste regulations if it is disposed on-site, as happens at the single Montana elemental phosphorus facility. Idaho's solid waste regulations do not address any mineral processing wastes, though the state does ban the use of elemental phosphorus furnace slag in construction materials for habitable structures. Only Tennessee appears to actively regulate surface water discharges from furnace slag piles, while none of the states specifically apply fugitive dust control requirements to these wastes.

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[37] Recent revisions of risk factors for radiation exposure indicate that actual risks may even be a factor of two higher than those stated here.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of on-site management of elemental phosphorus slag, the absence of documented damages caused by on-site disposal of this material, and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating elemental phosphorus slag under RCRA Subtitle C.

Chapter 8

Ferrous Metals Production

For the purposes of this report, the ferrous metal industry consists of 28 facilities. These facilities were, as of September 1989, active and reportedly generating one or more of the following special wastes from mineral processing: iron blast furnace slag, iron blast furnace air pollution control dust/sludge, steel open hearth furnace (OHF) or basic oxygen furnace (BOF) slag, and/or steel OHF or BOF air pollution control dust/sludge. Of the 28 reportedly active facilities producing ferrous metals, as indicated in Exhibit 8-1, 24 facilities reported generating both iron and steel wastes at an integrated facility, two reported generating only iron production wastes and two reported generating only steel production wastes. Of the 26 active steel mills, 23 employ basic oxygen furnaces, two employ open hearth furnaces, and one operates both types of steel furnaces.[1] Several iron foundry operations were surveyed but reportedly did not generate any special wastes from mineral processing, and hence, have not been included in this report. The data included in this chapter are discussed in additional detail in the appendices to and the supporting public docket for this report.

8.1 Industry Overview

Iron blast furnaces produce molten iron that can be cast (molded) into products, but is primarily used as the mineral feedstock for steel production. Steel furnaces produce a molten steel that can be cast, forged, rolled, or alloyed in the production of a variety of materials. On a tonnage basis, about nine-tenths of the metal consumed in the United States is iron or steel. Iron and steel are used in the manufacture of transportation vehicles, machinery, pipes and tanks, cans and containers, and the construction of large buildings, roadway superstructures, and bridges.[2]

The 28 ferrous metal facilities are located in ten states; 21 of these facilities are in five states (Ohio, Pennsylvania, Indiana, Illinois, and Michigan) that are situated around the Great Lakes, with immediate access to the lake transport of beneficiated iron ore (taconite pellets). The average age of the iron facilities is approximately forty-six years. The oldest active furnace reportedly is at the US Steel facility in Lorain, Ohio, and is a blast furnace built in 1899 and modernized in 1968. All iron facilities have undergone modernization during the past twenty years; at least 16 of the active facilities performed some modernization during the last 5 years. The average age of the BOFs is twenty-two years, with dates of initial operation ranging from 1958 to 1977; about half of these facilities have undergone modernization. The oldest active OHF operation reportedly commenced operation in 1938; all three of these facilities have been modernized, two within the last three years.

The annual aggregate production capacity of the iron facilities is 72.1 million metric tons; the production was reported to be 49.1 million metric tons, resulting in an estimated average capacity utilization rate of 68.1 percent.[3] The total annual aggregate production capacity was 72.2 million metric tons for the basic oxygen furnaces and about 5.3 million metric tons for the open hearth furnaces.[4] Total production was

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[1] The ferrous metals sector has, in addition to these 28 primary processing facilities, many secondary processors (e.g., electric arc furnaces, all of which primarily use scrap for feedstock). The Mining Waste Exclusion is limited to facilities that use less than 50 percent scrap as feedstock, thus only steel facilities that do not rely primarily upon scrap as iron feedstock are considered here.

[2] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 412.

[3] Environmental Protection Agency, 1989. "National Survey of Solid Wastes from Mineral Processing Facilities," 1989.

[4] The average production capacities and utilization rates do not include data from one confidential facility with basic oxygen furnace operations and one confidential facility with open hearth furnace operation.

Exhibit 8-1

Domestic Iron and Steel Producers

Owner	Location	Type of Operation
Acme	Riverdale, IL	Iron;[a] BOF Steel
Allegheny	Brackenridge, PA	BOF Steel
Armco	Ashland, KY	Iron; BOF Steel
Armco	Middletown, OH	Iron; BOF Steel
Bethlehem Steel	Bethlehem, PA	Iron; BOF Steel
Bethlehem Steel	Burns Harbor, IN	Iron; BOF, Steel
Bethlehem Steel	Sparrows Point, MD	Iron; BOF, OHF Steel
Geneva	Orem, UT	Iron; OHF Steel
Gulf States Steel	Gadsden, AL	Iron; BOF Steel
Inland Steel	E. Chicago, IN	Iron; BOF Steel
LTV	E. Cleveland, OH	Iron; BOF Steel
LTV	Indiana Harbor, IN	Iron; BOF Steel
LTV	W. Cleveland, OH	Iron; BOF Steel
McLouth Steel	Trenton, MI	Iron; BOF Steel
National Steel	Escora, MI	Iron; BOF Steel
National Steel	Granite City, IL	Iron; BOF Steel
Rouge Steel	Dearborn, MI	Iron; BOF Steel
Sharon Steel	Farrell, PA	Iron; BOF Steel
Shenango	Pittsburgh, PA	Iron
US Steel	Braddock, PA	Iron; BOF Steel
US Steel	Gary, IN	Iron; BOF Steel
US Steel	Fairfield, AL	Iron; BOF Steel
US Steel	Fairless Hills, PA	Iron; OHF Steel
US Steel	Lorain, OH	Iron; BOF Steel
Warren Steel	Warren, OH	Iron; BOF Steel
Weirton Steel	Weirton, WV	Iron; BOF Steel
Wheeling-Pittsburgh Steel	Mingo Junction, OH	Iron; BOF Steel
Wheeling-Pittsburgh Steel	Steubenville, OH	Iron; BOF Steel[b]

(a) Acme operates two blast furnaces, labeled A and B, at their Chicago Plant, Chicago, IL as reported in Iron and Steel Maker, Volume 15, No.1; January 1988. They reported, however, no Bevill waste from blast furnace operations in the 1989 "National Survey of Solid Wastes from Mineral Processing Facilities".

(b) Bureau of Mines has indicated that Wheeling-Pittsburgh Steel/Steubenville has a BOF steel operation; the company, however, reported no steel production or generation of special wastes from steelmaking. EPA has assumed no production is presently occuring.

50.2 million metric tons for the basic oxygen furnaces and 2.4 million metric tons for the open hearth furnaces.[5] The estimated 1988 average capacity utilization rate was, therefore, 69.5 percent for the basic oxygen furnaces and 45.3 percent for the open hearth furnaces.[6]

Overall primary production of pig iron was steady through the latter part of the 1980s, while production of raw steel experienced a steady increase. Between 1985 and 1989, primary production of pig iron averaged 46,000,000 metric tons, with almost all production being delivered to steel-making furnaces located at the same site. Imports for consumption and exports of pig iron were negligible during the 1985 to 1989 period. Production of raw steel steadily increased from 74,000,000 metric tons in 1989 to 91,000,000 metric tons in 1988, with a slight decrease of 3,000,000 metric tons in 1989. Imports of steel declined 28 percent (from 23,000,000 metric tons to 17,000,000 metric tons) reflecting the relatively weak dollar and the worldwide strength of the steel market. Due to the same factors, steel exports increased 300 percent (1,000,000 metric tons to 4,000,000 metric tons).[7]

The long-term trend of declining steel-making capacity since 1978 (145,000,000 metric tons) seems to have reversed recently. The capacity, reported by the American Iron and Steel Institute, has increased from 102,000,000 metric tons in 1988 to 104,000,000 metric tons in 1989. Approximately one-half of this increase can be attributed to the start-up of two minimills and reactivation of an inactive minimill. Raw steel production has experienced production levels well above those of the mid 1980s, with steel companies reporting profits for the last three years.[8]

Iron is produced either by blast furnaces or by one of several direct reduction processes; blast furnaces, however, account for over 98 percent of total domestic iron production.[9] The modern blast furnace consists of a refractory-lined steel shaft in which a charge is continuously added to the top through a gas seal. The charge consists primarily of iron ore, sinter, or pellets; coke; and limestone or dolomite. Iron and steel scrap may be added in small amounts. Near the bottom of the furnace, preheated air is blown in. The coke is combusted to produce carbon monoxide, the iron ore is reduced to iron by the carbon monoxide, and the silica and alumina in the ore and coke ash is fluxed with limestone to form a slag that absorbs much of the sulfur from the charge. Molten iron and slag are intermittently tapped from the hearth at the bottom. The slag is drawn off and processed. The product, pig iron, is removed and typically cooled, then transported to a steel mill operation, as depicted in Exhibit 8-2.

All contemporary steelmaking processes convert pig iron, scrap, or direct-reduced iron, or mixtures of these, into steel by a refining process that lowers the carbon and silicon content and removes impurities (mainly phosphorus and sulfur). Three major processes are used for making steel, based on different furnace types: the open hearth furnace, accounting for 2-4 percent of total domestic steel production; the basic oxygen furnace, with 56-59 percent of the total; and the electric arc furnace accounting for the remainder. The latter predominantly uses scrap (i.e., non-mineral material) as feed and is not discussed further in this report. The open-hearth process was prevalent in the U.S. between 1908 and 1969, but its use has diminished. The basic oxygen process has supplanted it as the predominant primary steel-making process, currently making up approximately 95 percent of domestic primary steel production.[10]

During the open-hearth process, a relatively shallow bath of metal is heated by a flame that passes over the bath from the burners at one end of the furnace while the hot gases resulting from combustion are pulled out the other end. The heat from the exhaust gas is retained in the exhaust system's brick liners, which

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[5] The average production capacities and utilization rates do not include data from one confidential facility with basic oxygen furnace operations and one confidential facility with open hearth furnace operation.

[6] Environmental Protection Agency, 1989. "National Survey of Solid Wastes from Mineral Processing Facilities," 1989.

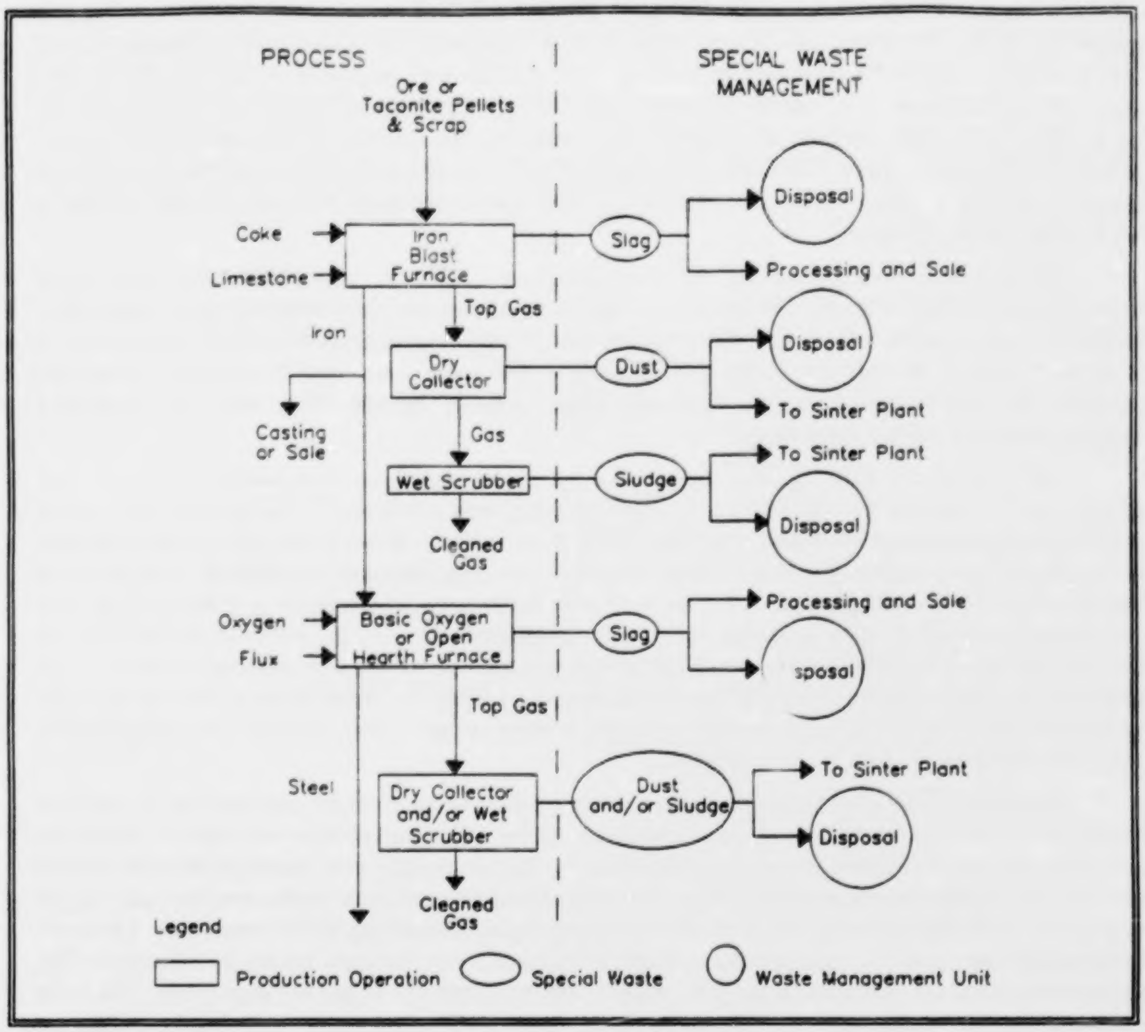
[7] Anthony T. Peters, U.S. Bureau of Mines, Mineral Commodity Summaries, 1990 Ed., p. 88.

[8] Ibid., p. 88-89.

[9] American Iron and Steel Institute, 1984. "Annual Statistical Report," 1984, p. 78.

[10] Bureau of Mines, 1987. Minerals Yearbook, Volume I, printed 1989, p. 511.

Exhibit 8-2
Ferrous Metals Production


PROCESS
SPECIAL WASTE MANAGEMENT
Ore or Taconite Pellets & Scrap
Coke
Limestone
Iron Blast Furnace
Slag
Disposal
Processing and Sale
Top Gas
Iron
Dry Collector
Dust
Disposal
To Sinter Plant
Casting or Sale
Gas
Wet Scrubber
Sludge
To Sinter Plant
Disposal
Cleaned Gas
Oxygen
Flux
Basic Oxygen or Open Hearth Furnace
Slag
Processing and Sale
sposal
Top Gas
Steel
Dry Collector and/or Wet Scrubber
Dust and/or Sludge
To Sinter Plant
Disposal
Cleaned Gas
Legend
Production Operation
Special Waste
Waste Management Unit

are known as checker-brick regenerators. Periodically the direction of the flame is reversed, and air is drawn through what had been the exhaust system; the hot checker-bricks preheat the air before it is used in the combustion in the furnace. Impurities are oxidized during the process and fluxes form a slag; this slag, the special waste, is drawn off and processed or discarded.

The basic oxygen process uses a jet of pure oxygen that is injected into the molten metal by a lance of regulated height in a basic refractory-lined converter. Excess carbon, silicon, and other reactive elements are oxidized during the controlled blows, and fluxes are added to form a slag. This slag, one of the special wastes, is drawn off and processed or discarded.

In all three operations, gases from the furnace must be cleaned in order to meet air pollution control requirements. Facilities may use dry collection or wet scrubbers or, as is most often practiced, both types of controls. Large volumes of dust and scrubber sludge are collected and processed or disposed; these air pollution control residuals are also special wastes.

Based on a review of available data, the Agency believes that the characteristics of the furnace slag from the BOF and OHF processes are similar. Thus, in the remainder of this chapter, no distinction is made between BOF slag and OHF slag; instead, the term "steel furnace slag" is used. For the same reasons APC dusts/sludges from BOFs and OHFs are discussed under the general term "steel furnace APC dust/sludge."

8.2 Waste Characteristics, Generation, and Current Management Practices

Ferrous metal production operations generate four special mineral processing wastes: iron blast furnace slag, iron blast furnace air pollution control dust/sludge, steel furnace slag, and steel furnace air pollution control dust/sludge.

Several comments received by EPA on the rulemaking proposals that established the scope of this report indicated that iron and steel slags should not be considered solid wastes. Based on the information on slag storage, disposal, and utilization presented in this chapter and the definition of solid waste (40 CFR 261.2), some iron and steel slags are solid wastes. EPA recognizes, however, that there may be justification for reconsideration of this position, and will, accordingly, consider comments on this issue. If EPA were to decide that a change is warranted, this change could only be effected through a formal rulemaking process.

Iron Blast Furnace Slag

In 1988, iron blast furnace slag was generated at 26 of the 28 ferrous metal production facilities in the U.S. -- all twenty-four integrated iron/steel facilities and two additional iron blast furnace operations.

Blast furnace slag contains oxides of silicon, aluminum, calcium, and magnesium, along with other trace elements. There are three types of blast furnace slag: air-cooled, granulated, and expanded. Air cooled slag comprises approximately ninety percent of all blast furnace slag produced. The physical characteristics of the slags are in large part determined by the methods used to cool the molten slag. All facilities characterized their slags as solid, though slag is molten at the point of generation.

Non-confidential waste generation rate data were reported for all 26 facilities generating iron blast furnace slag. The aggregate annual industry-wide generation of all iron blast furnace slag by the 26 facilities was 18.8 million metric tons in 1988, yielding a facility average of over 724,000 metric tons per year. Reported facility generation rates ranged from 95,000 to 8.0 million metric tons. The average waste-to-product ratio (i.e., metric ton of iron blast furnace slag to metric ton of pig iron) was 0.384 in 1988.

The primary management practice for iron blast furnace slag is processing (e.g., granulating, expanding, crushing, sizing) and sale for use as aggregate. One facility, as part of a Corp of Engineers approved fill project, deposits its slag in an adjacent water body in order to buildup land area that is intended for use in managing other waste materials.[11]

Using available data on the composition of blast furnace slag, EPA evaluated whether the slag exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on analyses of 17 samples from eight facilities, the Agency does not believe the slag is corrosive, reactive, ignitable, or EP toxic. Consequently, even in the absence of the regulatory exemption provided by the Mining Waste Exclusion, EPA does not believe that this material would be subject to regulation as a hazardous waste.

Iron Blast Furnace Air Pollution Control (APC) Dust/Sludge

In 1988, iron blast furnace APC dust/sludge was generated at 26 of the 28 ferrous metal facilities in the U.S., including all 24 integrated iron/steel facilities and the two additional iron blast furnace operations.

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[11] Bureau of Mines, 1990. Personal Communications with BOM Commodity Specialist, 27 June, 1990.

Air pollution control (APC) devices treat the top gases emitted from iron blast furnaces. The air pollution control devices generate either dusts or sludges. APC dust/sludge is composed primarily of iron, calcium, silicon, magnesium, manganese, and aluminum.

Non-confidential waste generation rate data were reported for all 26 facilities generating iron blast furnace APC dust/sludge. The aggregate annual industry-wide generation of all iron APC dust/sludge by these facilities was approximately 1.2 million metric tons in 1988, yielding a facility average of nearly 52,000 metric tons per year. Reported facility generation rates ranged from 6,000 to 136,000 metric tons. The average waste-to-product ratio (i.e., metric ton of iron blast furnace APC dust/sludge to metric ton of pig iron) was 0.026 in 1988.

As shown in Exhibit 8-3, the two primary waste management practices at the iron facilities regarding APC dust/sludge are disposal in on-site units and the return of the material to the production process via the sinter plant operation or blast furnace.

Using available data on the composition of blast furnace APC dust/sludge, EPA evaluated whether this material exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and EP toxicity. Based on available information and best professional judgment, the Agency does not believe that the dust/sludge is corrosive, reactive, or ignitable, but some sludge exhibits the characteristic of EP toxicity at some facilities. EP toxicity test concentrations of all eight inorganic constituents with regulatory levels are available for the sludge from 16 facilities. Of these constituents, only selenium and lead concentrations exceeded the EP toxicity levels. Of 64 samples analyzed, concentrations of selenium exceeded the EP toxicity regulatory level in only 1 sample of the blast furnace APC sludge leachate (from the Fairless Hills facility), and in that case, only by a factor of 1.07 (i.e., seven percent over the standard). Lead concentrations exceeded the EP toxicity level in 4 of 70 samples analyzed, and by as much as a factor of 5.8. These 4 samples represented blast furnace APC sludge from the Sparrows Point, E. Cleveland, and Fairless Hills facilities. Lead and selenium concentrations as determined by SPLP analyses did not exceed the EP toxicity regulatory levels. In general, it is not likely that this waste would be regulated as a hazardous waste if it were to be removed from the Mining Waste Exclusion, because it would pass the EP toxicity test (which is best applied using multiple samples and a confidence limit) at most or all facilities.

Steel Furnace Slag

In 1988, steel furnace slag was generated at 26 of the 28 ferrous metal production facilities in the U.S. including all twenty-four integrated iron/steel facilities and two additional steel-producing facilities. Steel slag is composed of calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium, and magnesium. At the point of generation, the slag is in a molten form. The molten slag is air-cooled and is broken into varying sizes once processing (e.g., crushing) begins.

Non-confidential waste generation rate data were reported for 24 of the 26 facilities generating steel furnace slag. The aggregate annual industry-wide generation of all steel furnace slag by these 24 facilities was approximately 13.2 million metric tons in 1988, yielding a facility average of over 553,000 metric tons per year. Reported facility generation rates ranged from 18,000 to 3.3 million metric tons. The average waste-to-product ratio (metric ton of steel slag to metric ton of carbon steel) was 0.253 in 1988, ranging from 0.04 to 1.2.

The primary management practice for steel slag is processing (e.g., crushing, sizing) and sale for use as aggregate, though several facilities dispose or stockpile their steel slag.

Using available data on the composition of steel slag, EPA evaluated whether the slag exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and EP toxicity. Based on analyses of 13 samples from 9 facilities and best professional judgment, the Agency does not believe the slag is corrosive, reactive, ignitable, or EP toxic. Therefore, this material would be unlikely to be subjected to regulation as a hazardous waste at any facility that generates it, even if it were to be removed from the Mining Waste Exclusion.

Exhibit 8-3
Site-Specific Management of Iron APC Dust/Sludge in 1988

Practice	Number of Facilities	
	APC Dust	APC Sludge
Disposal on-site	6	8
Return to the Sinter Plant	10	6
Return to the Blast Furnace	0	1
Sold	1	1
Off-site management	7	9
Management practice not reported	1	0
Reported not generating waste type	1	1
TOTAL	26	26

Steel Furnace Air Pollution Control (APC) Dust/Sludge

Steel furnace APC dust/sludge is generated at 26 of the 28 ferrous metal production facilities in the U.S., including all 24 integrated iron/steel facilities and the two additional steel producing facilities. Steel APC dust/sludge consists mostly of iron, with smaller amounts of silicon, calcium, and other metals.

Non-confidential waste generation rate data were reported in the SWMPF Survey for only 11 of the 26 facilities generating steel APC dust/sludge. In addition, non-confidential waste generation data were reported by the American Iron and Steel Institute (AISI), a trade association representing the ferrous metals industry; the AISI data were used to supplement the incomplete survey data. Aggregate annual industry-wide generation of all steel APC dust/sludge by the 24 non-confidential facilities was approximately 1.4 million metric tons in 1988, yielding a facility average of nearly 61,000 metric tons per year. Reported facility generation rates ranged from 1,600 to 419,000 metric tons. The average waste-to-product ratio (metric ton of steel APC dust/sludge to metric ton of carbon steel) was 0.028 in 1988.

Waste management practices were reported for only ten of the 26 facilities. Eight of the ten reportedly dispose the APC dust/sludge on-site; the remaining two return the material to the production process via the sinter plant operation.

Using available data on the composition of steel furnace APC dust/sludge, EPA evaluated whether the sludge exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and EP toxicity. Based on available information and best professional judgment, the Agency does not believe the sludge is corrosive, reactive, or ignitable, but some sludge samples exhibit the characteristic of EP toxicity. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for the sludge from five facilities of interest. Of these constituents, only selenium concentrations exceeded the EP regulatory levels. Of seven samples analyzed, the concentration of selenium exceeded its regulatory level in only one sample (from the Lorain facility in Ohio), and in this one case, only by a factor of 1.46. Selenium concentrations as determined by SPLP analyses did not exceed the EP toxicity levels. Because selenium rarely exceeds EP toxicity levels when analyzed by the EP leach test, EPA believes that if this material is removed from the Mining Waste Exclusion, it will generally not be subject to regulation as a hazardous waste.

8.3 Potential and Documented Danger to Human Health and the Environment

In this section, EPA discusses two of the study factors required by Section 8002(p) of RCRA for four wastes generated in the ferrous metal production sector: (1) potential risk to human health and the environment associated with the management of iron blast furnace and steel furnace slag and iron blast furnace and steel furnace air pollution control dust/sludge; and (2) documented cases in which danger to human health and/or the environment has been proven. Overall conclusions about the hazards associated with each of these four wastes are based on the Agency's evaluation of these two factors.

Because the characteristics and management of the two slags is similar, EPA discusses them together in the following section, followed by a discussion of the two air pollution control dust/sludges.

8.3.1 Risks Associated With Iron Blast Furnace and Steel Furnace Slag

Any potential danger to human health and the environment from iron blast furnace and steel furnace slag is a function primarily of the composition of the slags, the management practices that are used, and the environmental settings of the facilities where the slags are generated and managed.

Iron Blast Furnace Slag Constituents of Concern

EPA identified chemical constituents in iron blast furnace slag that may pose a risk by collecting data on the composition of slag and evaluating the intrinsic hazard of chemical constituents present in the slag.

Data on Iron Blast Furnace Slag Composition

EPA's characterization of iron blast furnace slag and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW) and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations [illegible] 21 metals, cyanide, and a number of other inorganic constituents (i.e., chloride, fluoride, phosphorus, and sulfate) in total and leach test analyses, and represent samples from 13 of the 26 facilities that generate blast furnace slag.

Concentrations in total (solid) samples of blast furnace slag are consistent for most constituents across all data sources and facilities. Lead, zinc, and arsenic concentrations, however, vary over three orders of magnitude across the facilities.

Concentrations of constituents from leach test analyses of blast furnace slag generally are consistent across the data sources, types of leach tests (i.e., EP, SPLP, and TCLP), and facilities. Iron concentrations determined by EP analyses, however, are greater than two orders of magnitude higher than concentrations detected by SPLP analysis.

Process for Identifying Constituents of Concern

As discussed in detail in Chapter 2, the Agency evaluated the data summarized above to determine if blast furnace slag or slag leachate contain any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing the constituent concentrations to conservative screening criteria and then by evaluating the environmental persistence and mobility of constituents present in concentrations above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which the slag constituents are released to the environment and migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Concern

Of the 26 constituents analyzed in blast furnace slag solids, only chromium is present at concentrations exceeding a screening criterion. Chromium was detected at concentrations greater than a screening criterion: it exceeds the inhalation screening criterion in four of twelve slag samples (representing three of seven facilities). The maximum detected concentration of chromium exceeds the air pathway screening criterion by only a factor of six. Chromium concentrations greater than the criterion indicate that the slag could pose a cancer risk greater than $1x10^{-5}$ if slag dust were blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter. As discussed in the following section on release, transport, and exposure potential, EPA does not expect such large exposures to windblown dust because of the large particle size of the slag and the large distance to potential receptors.

Exhibit 8-4 presents the results of the comparisons for blast furnace slag leach test analyses to the risk screening criteria. This exhibit lists all constituents for which sample concentrations exceed a screening criterion. As shown, comparison of leach test concentrations of 20 constituents to surface and ground-water pathway screening criteria identified eight contaminants that are present at concentrations above the criteria. All of these contaminants are metals or other inorganics that do not degrade in the environment. Manganese and iron exceed a screening criterion in samples from at least 50 percent of all facilities from which samples were analyzed. These two constituents, as well as lead, arsenic, and silver exceed at least one screening criterion by factors of 10 or greater. The other constituents exceed screening criteria less frequently and by a narrower margin. Previous EPA analyses also indicate that the pH of aqueous extracts of iron blast furnace slag ranges from 5.0 to 11.9 standard units.[12] Leachate data collected as part of the damage cases confirm that leachate from the slag can be very basic (see Section 8.3.3). Despite these exceedances of the screening criteria, none of the samples contained any constituents in excess of the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- If slag leachate were released to a potential drinking water supply, and diluted less than tenfold during migration to a drinking water exposure point, long-term ingestion could cause adverse health effects due to the presence of high concentrations of lead, arsenic, and antimony. The concentration of arsenic in diluted slag leachate could pose a lifetime cancer risk of greater than $1x10^{-5}$.
- Lead, aluminum, silver, and mercury in the slag leachate, as well as its alkalinity, could present a threat to aquatic organisms if the leachate migrates (with less than 100-fold dilution) to surface waters.
- Manganese, iron, and lead in the slag leachate, as well its alkalinity, could restrict the potential future uses of affected ground- and surface water resources if released and diluted by a factor of 10 or less.

EPA emphasizes that these exceedances of the screening criteria do not indicate that the slag is actually causing the risks outlined above. Instead, the exceedances provide evidence that the slag could pose these threats under hypothetical, very conservative release and exposure conditions. The actual slag management conditions that influence risks are examined later in this section.

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[12] EPA. 1979. Environmental and Resource Conservation Considerations of Steel Industry Solid Waste. Office of Research and Development. EPA-600/2-79-074.

Exhibit 8-4
Potential Constituents of Concern in Iron Blast Furnace Slag Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Manganese	6 / 6	Resource Damage	6 / 6	5 / 5
Iron	6 / 6	Resource Damage	4 / 6	3 / 5
Lead	10 / 18	Human Health Resource Damage Aquatic Ecological	5 / 18 7 / 18 2 / 18	2 / 9 3 / 9 2 / 9
Arsenic	4 / 18	Human Health*	4 / 18	1 / 9
Aluminum	6 / 6	Aquatic Ecological	3 / 6	2 / 5
Silver	5 / 18	Aquatic Ecological	3 / 18	2 / 9
Mercury	5 / 18	Aquatic Ecological	1 / 18	1 / 9
Antimony(c)	1 / 6	Human Health	1 / 6	1 / 5

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP leach test results.

Steel Furnace Slag Constituents of Concern

Using the same process outlined above, EPA identified chemical constituents in carbon steel furnace slag that may pose a risk by collecting data on the composition of the slag, and evaluating the intrinsic hazard of the slag's chemical constituents.

Data on Steel Furnace Slag Composition

EPA's characterization of steel furnace slag and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW) and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, cyanide, ammonia, and a number of other inorganic constituents (i.e., phosphorus, phosphate, sulfate, and fluoride) in total and leach test analyses, and represent samples from 14 of the 26 facilities that generate steel furnace slag.

Concentrations in total (solid) samples of the steel furnace slag are consistent for most constituents across all data sources and facilities. Mercury and silver concentrations, however, vary over three orders of magnitude across the facilities.

Concentrations of constituents from leach test analyses of the steel furnace slag generally are consistent across the data sources and facilities. In the EP analyses, however, arsenic, iron, and manganese concentrations varied over approximately three orders of magnitude across the facilities. For most constituents, maximum EP leach test concentrations are somewhat higher than maximum SPLP leach test concentrations.

Identified Constituents of Concern

Exhibits 8-5 and 8-6 present the results of the comparisons for steel furnace slag solid analyses and leach test analyses, respectively, to the risk screening criteria. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Of the 24 constituents analyzed in steel furnace slag solids, only chromium, thallium, manganese, arsenic, and nickel are present at concentrations exceeding the screening criteria (see Exhibit 8-5). All of these constituents are metals or other inorganics that do not degrade in the environment. Chromium, thallium, and manganese concentrations exceed the criteria most frequently -- in 57 to 100 percent of the samples and in samples from at least one-half of the facilities analyzed. Maximum concentrations of chromium, thallium, and arsenic exceed screening criteria by factors of greater than 10. All other constituents exceed the criteria by a narrower margin.

- Chromium, thallium, and arsenic concentrations exceed the ingestion criteria. This indicates that, if the slag (or soil contaminated with the slag) is incidentally ingested on a routine basis (e.g., if children are allowed to play on abandoned slag piles), then these constituents may cause adverse health effects. The concentration of arsenic in the slag could pose a lifetime cancer risk exceeding $1x10^{-5}$ if incidentally ingested.
- Chromium, manganese, arsenic, and nickel concentrations exceed the health-based screening criteria for inhalation. This indicates that these constituents could cause adverse effects on the central nervous system (manganese) or pose a cancer risk greater than $1x10^{-5}$ (chromium, arsenic, and nickel) if slag dust were blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter. Based on the large particle size of the slag and the large distance to potential receptors, however, EPA does not expect such large exposures to windblown dust (as discussed in the next section).

Based on a comparison of leach test concentrations of 23 constituents to surface and ground-water pathway screening criteria (see Exhibit 8-6), eight contaminants in the slag leachate were detected in concentrations above the criteria. All of these contaminants are metals or other inorganics that do not degrade in the environment. Manganese, fluoride, arsenic, and lead concentrations in samples from at least 30 percent of the facilities analyzed exceed screening criteria. Maximum concentrations of manganese, arsenic, and iron exceed screening criteria by factors of more than 10. Leachate data collected during the damage case investigation (see Section 8.3.3) also indicate that the slag leachate can be very basic. However, no constituents were measured in the leachate in concentrations that exceed the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Concentrations of fluoride, arsenic, lead, and barium in steel furnace slag leachate exceed health risk (drinking water) screening criteria. This indicates that, if slag leachate were released and diluted less than tenfold during migration to a drinking water exposure point, long-term ingestion could cause adverse health effects due to the presence of these constituents. The concentration of arsenic in diluted slag leachate could pose a cancer risk of greater than $1x10^{-5}$.
- Lead and silver in the slag leachate, as well as its alkalinity, could present a threat to aquatic organisms if it migrates (with less than 100-fold dilution) to surface waters.
- Manganese, fluoride, arsenic, lead, iron, molybdenum, and barium in the slag leachate, as well as its alkalinity, could restrict the potential future uses of affected ground- and surface water resources if released and diluted by a factor of 10 or less.

Again, EPA emphasizes that the criteria exceedances outlined above should not be interpreted as proof of hazard, but rather indicate the need to examine the slag's release and exposure conditions in greater detail. The Agency therefore proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and managed the waste.

Exhibit 8-5
Potential Constituents of Concern in Steel Furnace Slag Solids[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Chromium	12 / 12	Inhalation* Ingestion	12 / 12 1 / 12	7 / 7 1 / 7
Thallium	4 / 7	Ingestion	4 / 7	3 / 6
Manganese	10 / 10	Inhalation	6 / 10	5 / 9
Arsenic	7 / 11	Ingestion* Inhalation*	3 / 11 2 / 11	3 / 8 2 / 8
Nickel	3 / 9	Inhalation	1 / 9	1 / 7

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

Exhibit 8-6
Potential Constituents of Concern in Steel Furnace Slag Leachate[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Manganese	3 / 6	Resource Damage	3 / 6	3 / 5
Fluoride	1 / 1	Human Health Resource Damage	1 / 1 1 / 1	1 / 1 1 / 1
Arsenic[(c)]	3 / 8	Human Health* Resource Damage	3 / 8 1 / 8	2 / 5 1 / 5
Lead	4 / 14	Human Health Resource Damage Aquatic Ecological	3 / 14 4 / 14 3 / 14	3 / 10 3 / 10 3 / 10
Silver	2 / 14	Aquatic Ecological	2 / 14	2 / 10
Iron	3 / 6	Resource Damage	1 / 6	1 / 5
Molybdenum	2 / 8	Resource Damage	1 / 8	1 / 7
Barium	7 / 14	Human Health Resource Damage	1 /14 1 [illegible]4	1 / 10 1 / 10

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP leach test results.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of blast furnace and steel furnace slag as they were generated and managed at six and seven plants, respectively, in 1988. For this analysis, the Agency did not have sufficient data to assess (1) the hazards of off-site use or disposal of the slags, (2) risks associated with variations in waste management practices or potentially exposed populations in the future, or (3) the hazards of alternative management practices. Alternative practices for the management of blast furnace and steel furnace slag, however, are discussed in Section 8.5.

The Agency evaluated the potential hazards posed by the management of blast furnace and steel furnace slag for only the facilities that provided information on on-site slag management units in their responses to the National Survey of Solid Wastes from Mineral Processing Facilities. Of the 20 facilities that generate blast furnace slag but are not evaluated below, 17 facilities responded that blast furnace slag is sold for processing and subsequent use, and 3 facilities identified on-site management units containing blast furnace slag (a stockpile, a temporary storage unit, and slag pits) but provided no details on the characteristics of these units. Of the 19 facilities that generate steel furnace slag but are not evaluated, one facility identified an on-site management unit containing this slag (i.e., a stockpile) but provided no details on the characteristics of this unit, one facility requested that all information in its survey be held confidential, and the other 17 facilities responded that all of the steel furnace slag that they generated in 1988 was recycled or processed and sold. Because the slag management units described by the facilities the Agency analyzed include both slag pits and stockpiles, such as might be present at the facilities that sell slag for processing and off-site use, EPA expects that the hazards at the facilities that are evaluated reflect the nature of the potential threats posed by blast furnace and steel furnace slag at the other facilities that generate these materials.

Ground-Water Release, Transport, and Exposure Potential

EPA and industry test data discussed above show that several constituents are capable of leaching from blast furnace and steel furnace slag in concentrations above the screening criteria. Considering only those constituents that are relatively mobile in ground water (given the existing slag management practices and expected pH levels of the leachate), blast furnace slag contaminants that pose the primary potential threat are arsenic and mercury, and steel furnace slag constituents that present the greatest potential threat are fluoride, arsenic, and molybdenum. In addition, the high pH of slag leachate conceivably could threaten ground-water resources. Based on an evaluation of management practices, hydrogeologic settings, and current ground-water use patterns, EPA concludes that the potential for ground water release and transport ranges from low to relatively high at the eleven facilities for which management unit information is available. However, the potential for significant exposure to any released contaminants appears low at most of these facilities.

Although their slag management units are not equipped with liners or other engineered controls to restrict releases to ground water, the Geneva, USX/Lorain, LTV/East Cleveland, Rouge, and Inland plants have relatively low ground-water contamination potential.

- Ground-water contamination potential is low at the Geneva, USX/Lorain, and LTV/East Cleveland plants because net ground-water recharge at these locations is moderately low (8 to 15 cm/yr) and aquifers are relatively deep (15 to 23 meters).
- The potential for ground-water contamination at Rouge is low because the uppermost useable aquifer lies beneath a confining layer. This confining layer is known to be an effective barrier because the underlying aquifer is artesian (i.e., it has a hydraulic head higher than the surrounding land surface).
- At the Inland plant, blast furnace slag is deposited in an area along the shore of Lake Michigan. Because slag is placed in the lake, slag constituents can readily be leached by lake waters. Nonetheless, there is little potential for contamination of the underlying ground water because of the large depth to the usable aquifer underlying the facility (21 meters).

At the Geneva plant, downgradient use of ground water may occur at a distance of less than 100 meters from the facility. However, considering the low release potential at this site and the generally low concentrations of contaminants in the leachate, the concentrations at this exposure point are expected to be below levels of concern. At the other plants with low ground-water release potential, the potential for exposure is also low because there are no downgradient private residences or public supply wells within 1.6 km (1 mile) downgradient of the plants.

Ground-water release potential is moderate at USX/Fairless Hills, Sharon, Allegheny, and Warren. Because slag management units at these plants do not have ground-water release controls, infiltrating precipitation (net ground-water recharge at these plants ranges from 15 to 23 cm/yr) can leach slag constituents directly into the subsurface and into ground water that occurs 4 to 6 meters below the land surface. Releases to ground water at all four plants, if not sufficiently diluted, could render affected aquifers unsuitable for potential uses. Any ground-water contamination at the Fairless Hills and Warren plants conceivably could result in drinking water exposures at a residence located 150 meters downgradient of the Fairless Hills facility and a public supply well (serving 160 people) located 460 meters downgradient of the Warren facility. Contaminant concentrations at these exposure points, however, are likely to be below levels of concern.

Slag management at the Bethlehem/Bethlehem and Weirton plants poses a relatively high potential for contaminants to migrate into ground water.

- The landfill used to dispose of steel furnace slag at Bethlehem/Bethlehem is located only 3 meters above ground water and recharge in this area is 23 cm/yr.
- At Weirton, blast furnace slag is cooled with water in pits that are lined with recompacted local clay and steel furnace slag is stored in a slag pile that has no ground-water release controls such as a liner or leachate collection system. The clay liner at the blast furnace slag pit may limit the potential for slag cooling water to seep from these pits to the subsurface, but if this liner should fail, releases could migrate through the sandy subsurface materials to the usable aquifer located just over 3 meters (10 feet) below the bottom of the pits.

Despite these unfavorable conditions, no ground-water contamination attributable to the slag management units at these sites has been observed. If such contamination were to occur in the future, it could render ground water unsuitable for potential uses but would not threaten current human populations because there are no downgradient wells within 1.6 km (1 mile) of either facility.

Surface Water Release, Transport, and Exposure Potential

In theory, constituents of potential concern in blast furnace and steel furnace slag could enter surface waters by migration of slag leachate through ground water that discharges to surface water, or direct overland (stormwater) run-off of dissolved or suspended slag materials. The constituent concentrations and pH levels detected in blast furnace and steel furnace slag leachate confirm that the potential exists for slag contaminants to migrate into surface water in a leached form. The potential for overland release of slag particles to surface waters is limited considerably by the generally large size of the slag fragments. A small fraction of the slag material, however, may consist of fragments that are small enough to be erodible. Only particles that are 0.1 mm or less in size tend to be appreciably erodible,[13] and only a very small fraction of the blast furnace and steel furnace slag solids are expected to be in this size range.

Based on environmental settings of the facilities and the presence of stormwater run-on/run-off controls at slag management units, the potential for contaminants from blast furnace and steel furnace slag to migrate into surface water at the eleven facilities appears to range from relatively low to relatively high. The potential for significant exposure to these contaminants, however, appears moderate at most.

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[13] As indicated by the soil erodibility factor of the USDA's Universal Soil Loss Equation.

The slag stockpile at Geneva has a relatively low potential for causing surface water contamination. Overland releases from this facility are limited by stormwater run-off controls and ground-water releases are limited by the large depth to the aquifer and small net recharge.

Slag management units at Allegheny, Weirton, and Bethlehem/Bethlehem pose a moderate threat to surface waters. The units at these facilities have a limited potential for causing surface water contamination via overland flow of erodible slag particles or leached slag constituents because the piles and pits at these facilities are equipped with run-off controls. However, as discussed above, the potential for ground-water contamination from the slag management units at these plants is moderate to high, and potential ground-water contaminants may discharge to the surface waters that are within 50 meters of the facilities. Furthermore, the Weirton and Bethlehem/Bethlehem facilities are located in 100-year floodplains and, therefore, are susceptible to severe erosion that might occur in the event of a flood. Even if contamination from the slag management units at these facilities did reach the nearby Allegheny, Ohio, and Lehigh rivers, the contaminants would likely be diluted below levels of concern in the rivers' large flow (the annual average flow of these rivers ranges from 1,400 mgd to 22,000 mgd).

Slag management units at the other seven facilities have a relatively high potential to contaminate surface waters. The USX/Fairless, Inland, Rouge, Sharon, LTV/East Cleveland, Warren, and USX/Lorain facilities are all located adjacent to or very near surface waters and have no controls to limit ground-water infiltration or stormwater run-off. The potential risks posed by releases from these plants depends on the size and current uses of the receiving water bodies.

- The Rouge, LTV/East Cleveland, and USX/Lorain plants pose moderate to low human health risks because contaminants from these facilities could enter rivers with moderate to relatively large flows (i.e., 145 to 580 mgd) that are used as drinking water supplies. The potential for adverse effects is highest at Rouge because the Rouge River has the smallest flow and is used as a drinking water supply for 1.2 million people (intake is 10 km downstream). The Cuyahoga and Black rivers near LTV/East Cleveland and USX/Lorain are larger than the Rouge River, but also used as a drinking water supply within 24 km downstream.
- Releases from the Sharon and Warren plants could potentially enter the Shenango and Mahoning rivers, respectively, where they would be diluted (the rivers' annual average flows are 430 and 580 mgd, respectively). If the contamination was not sufficiently diluted, it could endanger aquatic life and potential consumptive uses of the river water.
- Slag management units at USX/Fairless Hills and Inland are located adjacent to (or in) large water bodies (i.e., the Delaware River and Lake Michigan) that can assimilate large quantities of contaminants. Therefore, it is unlikely that releases from these facilities would adversely affect aquatic life or potential uses of these water bodies.

Air Release, Transport, and Exposure Potential

Because all of the constituents that exceed the inhalation screening criteria (i.e., chromium, manganese, arsenic, and nickel) are nonvolatile, blast furnace and steel furnace slag contaminants can only be released to air in the form of dust particles. Dust can be either blown into the air by wind or suspended in air by slag dumping and crushing operations. Factors that affect the potential for such airborne releases include the particle size of the slag, the height and exposed surface area of the slag management units, the slag moisture content, the use of dust suppression controls, and local wind speeds. The potential for exposure to airborne dust depends on the proximity to nearby residences.

The generally large size of blast furnace and steel furnace slag fragments limits the potential for release of airborne slag dust, because in general, only particles that are less than 100 micrometers (um) in diameter are wind suspendable and transportable. Within this range, moreover, only particles that are less than 30 um in diameter can be transported for considerable distances downwind, and only particles that are less than 10 um in diameter are respirable. The vast majority of blast furnace and steel furnace slag is substantially larger than 100 um and thus should not be suspendable, transportable, or respirable. It is likely that only a very small fraction of the slag will be weathered and aged (or crushed) into smaller particles that can be suspended in air and cause airborne exposures and related impacts.

Other factors that affect the potential for airborne release and exposure vary on a site-specific basis as follows:

- Dust suppression is practiced at the slag management units at Geneva, Allegheny, and Warren. However, because winds are sufficiently strong, if this control is not effective or is discontinued, small slag particles could be suspended and pose health risks at residences located within 100 meters of the facilities. The 1,500; 5,000; and 20,000 residents within 1.6 km (1 mile) of the Geneva, Allegheny, and Warren facilities, respectively, might then be exposed to airborne slag particles.
- Weirton and Rouge manage slag in small units (i.e., .04 to .46 acres) that are not equipped with dust controls. The small size of these units and the generally large size of slag fragments limit the potential for slag to become airborne and be respired. In the event that small slag particles are released to the air, exposures and associated risks would be higher at the Weirton facility than at Rouge because of the differences in distance to the nearest residence (25 m and 275 m, respectively) and the size of the nearby populations (15,000 and 12,000 people within 1.6 km (1 mile), respectively).
- At the USX/Fairless, Inland, Sharon, USX/Lorain, Bethlehem/Bethlehem, and LTV/East Cleveland facilities, the slag management units range from approximately .4 to 140 hectares (1 to 348 acres) in area. These units are not covered with either vegetation or a synthetic material, and the facilities do not use any dust suppression controls, such as sprinkling water on the units. However, the number of days with rain, which may suppress dust, is relatively large (95 to 160 days/yr). As a result, the surface of the slag is expected to be moist much of the time. Short term gusts of strong winds could produce wind erosion of fine particles. Based on these factors, the potential for dusting is moderate at all seven facilities. Windblown dust could lead to potential exposures at these facilities because the nearest residence in a predominant wind direction is less than 700 meters away and the population within 1.6 km (1 mile) ranges from 2,000 to 35,000.

Proximity to Sensitive Environments

Twenty-three of the 26 iron production facilities, and 21 of 26 steel production facilities are located in or near environments that are vulnerable or that have high resource value, such as wetlands, 100-year floodplains, fault zones, national forests, or endangered species habitats. In particular:

- The Geneva facility is located near the critical habitat of a federally listed endangered species -- the June Sucker. Because the critical habitat of this fish is upstream (in the Provo River) from the facility, it is unlikely that releases of waste constituents from the Geneva plant could threaten this habitat.
- Warren, Weirton, USX/Lorain, Shenango (iron only), LTV/East Cleveland, WP/Steubenville (iron only), W-P/Mingo Junction, National/Great Lakes, Bethlehem/Bethlehem, Rouge, Bethlehem/Sparrows Point, USX/Fairless Hills, Gulf States, National/Granite City, and USX/Braddock all have part of their facilities located within 100-year floodplains. Management of wastes in floodplains creates the potential for large, episodic releases caused by flood events.
- USX/Lorain, Bethlehem/Sparrows Point, and USX/Fairless Hills have wetlands (defined here to include swamps, marshes, bogs, and other similar areas) within their facility boundaries. Bethlehem/Burns Harbor, Inland, LTV/East Cleveland, LTV/Indiana Harbor, McLouth, USX/Gary, and Geneva are located within 1.6 km (1 mile) of wetlands. Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural water, provide flood and storm

damage protection, and afford a number of other benefits. Contamination from these sites could potentially cause adverse effects in adjacent or nearby wetlands.

- Bethlehem/Bethlehem and USX/Fairless Hills are located in an area of karst terrain characterized by sink holes and underground cavities developed by the action of water in soluble rock (such as limestone or dolomite). Solution cavities that may exist in the bedrock at this site could permit any ground-water contamination originating from the wastes to migrate in a largely unattenuated and undiluted fashion.
- USX/Fairfield and ARMCO/Ashland are located in fault zones. Any waste containment systems in fault zones are subject to episodic damages caused by earthquakes.
- Bethlehem/Burns Harbor is located within 1.6 km (1 mile) of a National Park. The air and water resources of the National Park potentially could be adversely affected by nearby waste management, and recreational activities at the park could allow exposures to waste constituents released from the nearby ferrous metal production facility.

8.3.2 Risks Associated With Iron Blast Furnace and Steel Furnace Air Pollution Control Dust/Sludge

Any potential danger to human health and the environment from iron blast furnace and steel furnace air pollution control (APC) dust/sludge is a function primarily of the composition of the wastes, the management practices that are used, and the environmental settings of the facilities where the wastes are generated and managed.

Blast Furnace APC Dust/Sludge Constituents of Concern

Using the same process outlined above for blast furnace slag, EPA identified chemical constituents in the blast furnace APC dust/sludge that may pose a risk by collecting data on the composition of the waste, and evaluating the intrinsic hazard of the waste's chemical constituents.

Data on Iron Blast Furnace APC Dust/Sludge Composition

EPA's characterization of blast furnace APC dust/sludge and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, cyanide, ammonia, and a number of other inorganic constituents (e.g., phosphorus, phosphate, fluoride, and sulfate) in total and leach test analyses, and represent samples from 17 of the 26 facilities that generate blast furnace APC dust/sludge.

Concentrations in total (solid) samples of the blast furnace APC dust/sludge are consistent for most constituents across all data sources and facilities. Arsenic, mercury, nickel, and selenium concentrations, however, vary over three orders of magnitude across the facilities.

Concentrations of many constituents from leach test analyses of blast furnace APC dust/sludge generally are consistent across the data sources and facilities. In the EP analyses, however, barium, cadmium, chromium, copper, cyanide, lead, and selenium concentrations vary over approximately three orders of magnitude across the facilities. Concentrations of many constituents are higher in EP leach test results than in either SPLP or TCLP test results. EP test concentrations of cadmium, copper, and iron are more than two orders of magnitude higher than the highest concentrations of these constituents in SPLP or TCLP results.

Identified Constituents of Concern

Exhibits 8-7 and 8-8 present the results of the comparisons for blast furnace APC dust/sludge solid analyses and leach test analyses, respectively, to the risk screening criteria. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Exhibit 8-7
Potential Constituents of Concern in Blast Furnace APC Dust/Sludge Solids[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Chromium	43 / 46	Inhalation*	43 / 46	13 / 13
Lead	46 / 47	Ingestion	23 / 47	11 / 14
Arsenic	15 / 36	Ingestion* Inhalation*	12 / 36 3 / 36	5 / 12 2 / 12
Antimony	6 / 9	Ingestion	1 / 9	1 / 7
Cadmium	27 / 44	Inhalation*	2 / 44	1 / 12

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

Of the 25 constituents analyzed in blast furnace APC dust/sludge solids, only chromium, lead, arsenic, antimony, and cadmium are present at concentrations exceeding the screening criteria (see Exhibit 8-7). Among these constituents, chromium and lead exceed the criteria most frequently -- in 51 to 93 percent of the samples analyzed and in samples from at least 11 of 14 facilities. Only chromium and antimony are present in concentrations greater than 10 times a screening criterion. All of these constituents are metals or other inorganics that do not degrade in the environment.

- Lead, arsenic, and antimony concentrations exceed the ingestion criteria. This indicates that, if the dust/sludge (or soil contaminated with the waste) is incidentally ingested on a routine basis (e.g., if children are allowed to play on abandoned waste piles), then these constituents may cause adverse health effects. The concentration of arsenic in the dust/sludge could pose a lifetime cancer risk greater than 1×10^{-5} if incidentally ingested on a routine basis.
- Chromium, arsenic, and cadmium concentrations exceed the health-based screening criteria for inhalation. This indicates that these constituents could pose a cancer risk greater than 1×10^{-5} if the dust were blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter.

Based on a comparison of leach test concentrations of 23 constituents to surface and ground-water pathway screening criteria (see Exhibit 8-8), 17 contaminants were detected at levels above the criteria. All of these constituents are persistent in the environment (i.e., they do not degrade). Manganese, lead, arsenic, aluminum, iron, zinc, and fluoride exceed at least one screening criterion in samples from at least 50 percent of all facilities at which they were analyzed. Although their concentrations exceed screening criteria less frequently, copper, mercury, and thallium concentrations are more than 40 times higher than the screening criteria. The only constituents that were detected in concentrations above the EP toxicity regulatory levels, however, were lead (in 4 of 70 samples) and selenium (in 1 of 64 samples). In addition, previous EPA analyses indicate that the pH of the aqueous fraction of the dust/sludge ranges from 9.5 to 11.7 standard units.[14]

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[14] EPA. 1979. Environmental and Resource Conservation Considerations of Steel Industry Solid Waste. Office of Research and Development. EPA-600/2-79-074.

Exhibit 8-8
Potential Constituents of Concern in Blast Furnace APC Dust/Sludge Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Manganese	6 / 6	Resource Damage	1 / 6	5 / 5
Lead	47 / 72	Human Health Resource Damage Aquatic Ecological	25 / 72 45 / 72 18 / 72	13 / 16 14 / 16 9 / 16
Arsenic	31 / 71	Human Health*	29 / 71	8 / 16
Aluminum	6 / 6	Aquatic Ecological	5 / 6	5 / 5
Iron	11 / 12	Resource Damage Aquatic Ecological	11 / 12 4 / 12	7 / 7 2 / 7
Zinc	27 / 31	Human Health Resource Damage Aquatic Ecological	3 / 31 3 / 31 17 / 31	2 / 11 2 / 11 10 / 11
Fluoride	5 / 5	Human Health Resource Damage	3 / 5 3 / 5	1 / 2 1 / 2
Selenium	19 / 66	Resource Damage Aquatic Ecological	4 / 66 [illegible] / 66	4 / 15 1 / 15
Thallium	2 / 8	Human Health	2 / 8	1 / 6
Mercury	16 / 70	Aquatic Ecological	3 / 70	3 / 15
Silver	23 / 59	Aquatic Ecological	14 / 59	7 / 15
Copper	22 / 34	Aquatic Ecological	4 / 34	2 / 9
Antimony	5 / 13	Human Health	3 / 13	2 / 7
Cadmium	39 / 72	Human Health Resource Damage Aquatic Ecological	2 / 72 4 / 72 3 / 72	2 / 16 4 / 16 3 / 16
Chromium	39 / 72	Resource Damage Aquatic Ecological	3 / 72 1 / 72	2 / 16 1 / 16
Barium	50 / 71	Resource Damage	2 / 71	1 / 15
Nickel	18 / 25	Aquatic Ecological	1 / 25	1 / 10

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

While this pH is well above the drinking water maximum contaminant level and the ambient water quality criterion for the protection of aquatic life, it does not exceed the limits used to define a corrosive hazardous waste. These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Concentrations of lead, arsenic, zinc, fluoride, thallium, antimony, and cadmium in blast furnace APC dust/sludge leachate exceed health risk (drinking water) screening criteria. This indicates that, if leachate from this waste were released and diluted by only a factor of 10 during migration to a drinking water exposure point, long-term ingestion could cause adverse health effects due to the presence of these constituents. The concentration of arsenic in diluted dust/sludge leachate could pose a cancer risk of greater than $1x10^{-5}$.
- Lead, aluminum, iron, zinc, selenium, mercury, silver, copper, cadmium, chromium, and nickel in the dust/sludge leachate, as well as its alkalinity, could present a threat to aquatic organisms if it migrates (with less than 100-fold dilution) to surface waters.
- Manganese, lead, iron, zinc, fluoride, selenium, cadmium, chromium, and barium in the APC dust/sludge leachate, as well as its alkalinity, could restrict the potential future uses of affected ground- and surface water resources if released and diluted by a factor of 10 or less.

These exceedances of the screening criteria, by themselves, do not demonstrate that the dust/sludge poses a significant risk, but rather indicate that the waste could pose a risk under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the dust/sludge to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the waste (see the following section on release, transport, and exposure potential).

Steel Furnace APC Dust/Sludge Constituents of Concern

Using the same process outlined above for the other three special wastes from ferrous metals production, EPA identified chemical constituents in the steel furnace APC dust/sludge that may pose a risk by collecting data on the composition of the waste, and evaluating the intrinsic hazard of the waste's chemical constituents.

Data on Steel Furnace APC Dust/Sludge Composition

EPA's characterization of steel furnace APC dust/sludge and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste and industry responses to a RCRA §3007 request. These data provide information on the concentrations of 20 metals, chloride, and sulfate in total and leach test analyses, and represent samples from 6 of the 26 facilities that generate steel furnace APC dust/sludge.

Concentrations in total (solid) samples of the steel furnace APC dust/sludge are consistent for most constituents across all data sources and facilities. Sulfate and zinc concentrations, however, vary over more than two orders of magnitude across the facilities.

Concentrations of constituents from leach test analyses of the steel furnace APC dust/sludge generally are consistent across the data sources and facilities. In the EP analyses, however, iron and zinc concentrations vary over approximately three orders of magnitude across the facilities. For most constituents, EP leach test results are somewhat higher than SPLP test results. Maximum EP leach test concentrations of iron, manganese, and zinc are more than two orders of magnitude higher than concentrations of the constituents reported for SPLP analyses.

Identified Constituents of Concern

Exhibits 8-9 and 8-10 present the results of the comparisons for steel furnace APC dust/sludge analyses and leach test analyses, respectively, to the risk screening criteria. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

From the 22 constituents analyzed in steel furnace APC dust/sludge solids, only chromium, lead, thallium, antimony, and arsenic are present at concentrations exceeding the screening criteria (see Exhibit 8-9). For all of these constituents except arsenic, concentrations detected in most samples analyzed (57 to 100 percent) exceed screening criteria, and concentrations in samples from at least two facilities exceed screening criteria. Maximum concentrations of chromium, thallium, and arsenic exceed screening criteria by a factor of more than 15. All of these constituents are metals or other inorganics that do not degrade in the environment.

- Lead, thallium, antimony, and arsenic concentrations exceed the ingestion criteria. This indicates that, if the dust/sludge (or soil contaminated with the waste) is incidentally ingested on a routine basis (e.g., if children are allowed to play on abandoned waste piles) these constituents may cause adverse health effects. The concentration of arsenic in the waste would pose a lifetime cancer risk greater than $1x10^{-5}$ if incidentally ingested.
- Chromium and arsenic concentrations exceed the health-based screening criteria for inhalation. This indicates that these constituents could pose a cancer risk greater than $1x10^{-5}$ if dust were blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter.

Exhibit 8-9
Potential Constituents of Concern in Basic Oxygen Furnace APC Dust/Sludge Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Chromium	8 / 8	Inhalation*	8 / 8	6 / 6
Lead	8 / 8	Ingestion	8 / 8	6 / 6
Thallium	4 / 7	Ingestion	4 / 7	2 / 5
Antimony	7 / 8	Ingestion	5 / 8	3 / 6
Arsenic	1 / 7	Ingestion* Ingestion*	1 / 7 1 / 7	1 / 5 1 / 5

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

Exhibit 8-10
Potential Constituents of Concern in Basic Oxygen Furnace APC Dust/Sludge Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Zinc	6 / 7	Human Health Resource Damage Aquatic Ecological	5 / 7 5 / 7 6 / 7	4 / 5 4 / 5 4 / 5
Manganese	7 / 7	Human Health Resource Damage Aquatic Ecological	1 / 7 7 / 7 1 / 7	1 / 5 5 / 5 1 / 5
Cadmium	6 / 8	Human Health Resource Damage Aquatic Ecological	3 / 8 5 / 8 5 / 8	3 / 6 4 / 6 4 / 6
Iron	5 / 7	Resource Damage Aquatic Ecological	3 / 7 1 / 7	3 / 5 1 / 5
Molybdenum[b]	3 / 7	Resource Damage	3 / 7	3 / 5
Lead	3 / 8	Human Health Resource Damage Aquatic Ecological	2 / 8 3 / 8 2 / 8	2 / 6 2 / 6 2 / 6
Selenium	1 / 8	Human Health Resource Damage Aquatic Ecological	1 / 8 1 / 8 1 / 8	1 / 6 1 / 6 1 / 6
Mercury	5 / 8	Aquatic Ecological	1 / 8	1 / 6

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Data for this constituent are from SPLP level test results.

Based on a comparison of leach test concentrations of 20 constituents to surface and ground-water pathway screening criteria (see Exhibit 8-10), eight contaminants were detected at levels above the criteria. All of these constituents are organics that do not degrade in the environment. Zinc, manganese, and cadmium concentrations exceed screening criteria in most (62 to 100 percent) of the analyses, and their concentrations in samples from at least two-thirds of the facilities analyzed exceed screening criteria. Maximum concentrations of manganese and iron exceed screening criteria by factors of greater than 100, and maximum concentrations of zinc, lead, and selenium exceed screening criteria by factors of greater than 10. Despite these exceedances of the screening criteria, only selenium was detected in a concentration that exceeds the EP toxicity regulatory level, and that was only in one sample.

Previous EPA analyses also indicate that the pH of aqueous extracts of steel furnace APC dust/sludge ranges from 5.4 to 12.5 standard units.[15] This range, especially at the high end, is outside the acceptable range established for drinking water and aquatic life protection.

The exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Concentrations of zinc, manganese, cadmium, lead, and selenium in steel furnace APC dust/sludge leachate exceed health risk (drinking water) screening criteria. This indicates that, if dust/sludge leachate were released and diluted less than ten-fold during migration to a drinking water exposure point, long-term ingestion could cause adverse health effects due to the presence of these constituents.
- Zinc, manganese, cadmium, iron, lead, selenium, and mercury in the dust/sludge leachate, as well as its alkalinity, could present a threat to aquatic organisms if it migrates (with less than 100-fold dilution) to surface waters.
- Zinc, manganese, cadmium, iron, molybdenum, lead, and selenium in the APC dust/sludge leachate, as well as its alkalinity, could restrict the potential future uses of affected ground- and surface-water resources if released and diluted by a factor of 10 or less.

These exceedances of the screening criteria, by themselves, do not prove that the dusts/sludges pose significant risks, but rather indicate that the wastes could pose a risk under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for these wastes to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the wastes.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of blast furnace and steel furnace APC dust/sludge as they were generated and managed at 17 plants in 1988. For this analysis, the Agency did not have sufficient data to assess (1) the hazards of off-site use or disposal of the wastes, (2) risks associated with variations in waste management practices or potentially exposed populations in the future, or (3) the hazards of alternative management practices. However, alternative practices for the management of blast furnace and steel furnace APC dust/sludge are discussed in Section 8.5. The hazards of off-site and alternative management practices were also within the scope of the damage case investigation, presented in Section 8.3.3.

The Agency evaluated the potential hazards posed by the management of blast furnace and steel furnace APC dust/sludges for only the facilities that provided information on on-site dust/sludge management units in their responses to the National Survey of Solid Wastes from Mineral Processing Facilities. Of the 11 facilities that generate blast furnace APC dust/sludge but were not evaluated, 5 facilities responded that this waste was sent off-site for disposal, 4 facilities stated that in 1988 all of this waste was recycled to process units, and 2 facilities identified on-site management units containing this waste (i.e., a stockpile and a waste pile) but provided no details on the characteristics of these units. Of the 15 facilities that generate steel furnace APC dust/sludge but were not evaluated, 2 facilities identified on-site management units containing this waste (i.e., a stockpile and a waste pile) but provided no details on the characteristics of these units, one facility requested that all information in its survey be held confidential, and the other 12 facilities did not provide information on the management of steel furnace APC dust/sludge. Because the management units that are evaluated include both disposal units (e.g., landfills and ponds) and temporary storage units (e.g., storage pads and transfer areas), such as might be present at the facilities that recycle the waste or send it off-site for disposal, EPA expects that the hazards at the facilities that are evaluated reflect the diversity and nature of the potential threats posed by blast furnace and steel furnace APC dust/sludge at the other facilities that generate these wastes.

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[15] EPA. 1979. Environmental and Resource Conservation Considerations of Steel Industry Solid Waste. Office of Research and Development. EPA-600/2-79-074.

Ground-Water Release, Transport, and Exposure Potential

EPA and industry test data discussed above show that several constituents are capable of leaching from blast furnace and steel furnace APC dust/sludge in concentrations that exceed the conservative screening criteria. Considering the existing waste management practices and pH of the leachate, the only constituents in blast furnace APC dust/sludge that are expected to be mobile in ground water if released are arsenic, fluoride, selenium, mercury, cadmium, and chromium. Steel furnace APC dust/sludge contaminants that are expected to be mobile if released include cadmium, molybdenum, selenium, and mercury. In addition, the pH of APC dust/sludge leachate may threaten ground-water resources. Based on an evaluation of management practices, hydrogeologic settings, and current ground-water use patterns, EPA concludes that the potential for ground-water release, transport, and exposure ranges from low to fairly high at the 17 facilities.

The majority of the iron and steel production plants (12 of the 17 facilities evaluated) manage blast furnace and steel furnace APC dust/sludge as a dry material in units such as stockpiles, landfills, waste piles, and transfer areas. Ground-water release potential from these types of units is determined by the infiltration of precipitation through the unit and into the underlying aquifer. Release, transport, and exposure potential at the 12 facilities managing the sludge/dust in dry units varies according to the use of engineered controls that limit infiltration, the nature of the subsurface geology, and the proximity of the management units to potential drinking water exposure locations.

- Although the Rouge waste pile containing blast furnace APC dust/sludge and the dust silo containing steel furnace APC dust/sludge are not equipped with liners or other engineered controls to restrict releases to ground water, the plant has relatively low ground-water contamination potential because the uppermost useable aquifer is protected by an upper confining layer. Because the underlying aquifer is artesian (i.e., it has a hydraulic head higher than the surrounding land surface), this confining layer is clearly an effective barrier to vertical ground-water flow.
- The Shenango plant temporarily stores blast furnace APC dust/sludge on a concrete-lined pad. This pad may limit infiltration to some extent, but because the pad does not have run-on/run-off controls to contain precipitation that falls on the pad or to limit overland flow of stormwater onto the pad, constituents could be released from this pad following precipitation events. Contaminants released from the pad could reach ground water quite readily because net recharge to ground water in this area is relatively high (18 cm/yr) and the aquifer is relatively shallow (3 meters). If contaminants from the dust/sludge were to enter the aquifer, they could pose health risks to existing populations via a public water supply well (serving 3,000 people) located 1,000 meters downgradient from the facility.
- The Warren and Bethlehem/Burns Harbor plants manage the blast furnace and steel furnace dust/sludge in landfills or piles with no engineered controls to limit ground-water infiltration of waste leachate. The potential for contaminant releases to ground water at these plants is moderate because net ground-water recharge is moderate to high (10 to 28 cm/yr) and the aquifers lie 3 to 6 meters below the land surface. Releases from the stockpile at the Warren plant may be limited somewhat by in-situ clay underlying the unit. Any releases that might occur at the Warren plant could endanger human health through drinking water exposures at a public supply well or private residences, located from 460 to 1,100 meters downgradient.
- The remaining eight facilities that manage the blast furnace and steel furnace dust/sludge in only landfills or piles (i.e., McLouth, LTV/East Cleveland, Bethlehem/Bethlehem, Bethlehem/Sparrows Point, USX/Fairfield, Gulf States, Inland, and LTV/West Cleveland) also have moderate to relatively high release potential but pose no current health risk via the ground-water pathway. The management units at these

facilities have no engineered ground-water release controls, and the moderate to high net recharge (8 to 20 cm/yr) where these facilities are located indicates a relatively high potential for releases to ground water from dust/sludge management units. However, ground water is not used as a source of drinking water within 1.6 km (1 mile) downgradient of all eight of these facilities. Any significant releases from these units could render ground-water supplies less desirable for use in the future.

Five facilities manage at least some blast furnace and steel furnace APC dust/sludge in impoundments. Three of these facilities (i.e., ARMCO/Middletown, LTV/Indiana Harbor, and National/Granite City) manage dust/sludges in both impoundments and dry units such as landfills and piles, and two facilities (i.e., Geneva and USX/Lorain) manage the wastes in impoundments only. Ground-water release potential from impoundments is a function of the permeability of the material lying between the impoundment and the aquifer, and the hydraulic head provided by standing liquids in the impoundment. Release, transport, and exposure potential at the five facilities that manage the sludge/dust in impoundments varies according to the use of engineered controls designed to limit seepage or infiltration of precipitation, the nature of the subsurface geology, and the proximity of the management units to potential drinking water exposure locations:

- The LTV/Indiana Harbor plant manages blast furnace APC dust/sludge in a sludge storage area, a lagoon, and a landfill. None of these units have engineered ground-water release controls such as liners or leachate collection systems. The potential for releases to ground water from the lagoon is high due to the hydraulic head of the standing water. For the other units, release potential is moderate because net recharge is moderate (10 cm/yr), subsurface materials are comprised primarily of sand, and the usable aquifer lies six meters below the land surface. There are no current uses of ground water within 1.6 km (1 mile) downgradient of this facility. Consequently, potential releases of dust/sludge contaminants would not pose current health risks but could render the ground water unsuitable for potential future uses.

- Ground-water release potential is relatively high at the ARMCO/Middletown plant because the dust/sludge management units (i.e., a landfill, two surface impoundments, and a waste pile) have no engineered ground-water release controls such as liners or leachate collection systems, and although in-situ clay underlies some of the units, the subsurface material is relatively permeable. Potential releases of dust/sludge contaminants from these units could pose a current health risk via drinking water exposures at a residence located 1,100 meters downgradient of the facility.

- Two of four dust/sludge management units at the National/Granite City plant have engineered controls: the flue dust pond is equipped with primary and secondary leachate collection systems, and the landfill has a synthetic liner. Releases from the other two units at this facility (i.e., the stabilization basin and backwash pond) are not controlled by any engineered features, but they may be limited somewhat by in-situ clay. The potential for ground-water releases from these two impoundments (and the flue dust pond and landfill, if the engineered controls should fail) is relatively high because subsurface material at this plant is comprised largely of sand and the aquifer lies only 2.5 meters below the land surface. Any potential ground-water contamination at this plant could restrict potential future uses but would not present a current health threat (i.e., the aquifer is not used as a source of drinking water within 1.6 km [1 mile] downgradient of this plant).

- The potential for releases from impoundments at the Geneva and USX/Lorain plants is relatively high because the management units are not equipped with engineered ground-water release controls and the subsurface material is moderately permeable. If releases were to occur from these units, ground water at both facilities might be rendered unsuitable for future uses, and contaminated ground water at the Geneva facility might also pose health risks from drinking water exposures at residences as close as 90 meters from the facility.

Surface Water Release, Transport, and Exposure Potential

Theoretically, constituents of potential concern in blast furnace and steel furnace APC dust/sludge could enter surface waters by migration of dust/sludge leachate through ground water that discharges to surface water, or by direct overland (stormwater) run-off of dissolved or suspended dust/sludge materials. The presence of several constituents in blast furnace and steel furnace APC dust/sludge leachate in concentrations that exceed the screening criteria confirms that the potential exists for contaminants from these wastes to migrate into surface water in a leached form. The small size of dust/ sludge particles (ranging from less than 0.02 mm up to 2 mm) also indicates a high potential for overland release of these wastes to surface waters. Particles that are 0.1 mm or smaller in size tend to be appreciably erodible[16], and the Agency expects that a significant fraction of the blast furnace and steel furnace APC dust/sludge is in this size range.

Based on environmental settings of the facilities, management unit characteristics, and the presence of stormwater run-on/run-off controls at some of the blast furnace APC dust/sludge management units, the potential for surface water contamination and human exposure due to releases from blast furnace and steel furnace APC dust/sludge at the 17 facilities is as follows:

- The National/Granite City plant poses very little threat to surface water because of the extreme distance (3,300 meters) to the nearest surface water -- the Mississippi River. Contaminants that might enter the surface water after migrating over this great distance would be diluted sufficiently that they would not pose a threat to any potential uses of the water or to aquatic life.
- The ARMCO/Middletown, LTV/West Cleveland, and Geneva plants pose moderate threats to surface water primarily via the discharge of contaminated ground water to surface waters. Transport of dust/sludge constituents to surface waters from units at these facilities may be limited by the relatively large distance (i.e., 240 to 370 meters) to the nearest surface waters, the use of run-off controls to limit stormwater release from some of the units at the ARMCO and LTV plants, and the small likelihood that sludge managed at the bottom of the impoundment in Geneva could be released to surface water via erosion. As discussed above, however, the potential for ground-water contamination at these facilities is moderate to high and ground-water discharging to surface water may pose threats to aquatic life and potential uses of the nearby surface waters. In addition, if not sufficiently diluted, releases from the LTV/West Cleveland plant could contaminate a drinking water intake located 23 km downstream of the plant.
- APC dust/sludge management at the remaining facilities poses a relatively great threat to surface water by both ground-water discharge to surface water and overland erosion of dust/sludge particles. Release potential from these facilities is high because (1) some of the units at these facilities do not have run-off controls to restrict the erosion and overland transport of dust/sludge particles in stormwater and (2) all these facilities are located less than 200 meters from nearby surface waters. The LTV/East Cleveland, Bethlehem/Sparrows Point, Bethlehem/Bethlehem, Shenango, and Rouge plants present additional hazards because they are located in 100-year floodplains and may release large amounts of contaminants to surface waters in flood events. Aquatic life and potential water uses are threatened from releases to surface waters at all of these plants. These risks are greatest at the USX/Fairfield, Gulf States, LTV/East Cleveland, and Rouge facilities where the receiving water bodies are relatively small (i.e., 70 to 600 mgd). Surface water contamination at the Rouge, Bethlehem/Burns Harbor, LTV/Indiana Harbor, and USX/Lorain plants, if not sufficiently diluted, could pose current health threats via drinking water supply intakes located 10 km, 19 km, 4 km, and 0.5 km downstream from these facilities. These intakes provide drinking water for 1.2 million; 230,000; 93,400; and 75,000 people, respectively.

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[16] As indicated by the soil erodibility factor of the USDA's Universal Soil Loss Equation.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern are nonvolatile, blast furnace and steel furnace APC dust/sludge contaminants can only be released to air in the form of dust particles. Dust can be either blown into the air by wind or suspended in air by waste dumping operations. Factors that affect the potential for such airborne releases include the particle size of the dust/sludge, the height and exposed surface area of the waste management unit, the moisture content of the waste as it is managed, the use of dust suppression controls, and local wind speeds. The potential for exposure to airborne dust depends on the proximity of the waste management units to people.

In general, particles that are less than 0.1 mm in diameter are wind suspendable and transportable. Within this range, however, only particles that are less than 0.03 mm in diameter can be transported for considerable distances downwind, and only particles that are less than 0.01 mm in diameter are respirable. A significant portion of APC dust/sludge particles are small enough to be wind suspendable and some fraction of the suspendable particles consists of smaller particles that can be respired. As discussed above, blast furnace dust/sludge contains arsenic, chromium, and cadmium at concentrations that exceed the screening criteria for inhalation.

APC dust/sludge is managed as dry material that is vulnerable to wind erosion at 15 of 17 facilities. Air pathway risks are expected to be minimal at the two facilities (i.e., Geneva and USX/Lorain) that manage APC dust/sludge in impoundments only. Based on consideration of environmental conditions, management unit characteristics, and distance to potential exposure points, the Agency concludes that air pathway release, transport, and exposure potential varies considerably among the 15 facilities that manage APC dust/sludge in dry units such as landfills and piles.

- Six facilities (McLouth, National/Granite City, Gulf States, LTV/East Cleveland, Bethlehem/Sparrows Point, and Rouge) practice dust suppression at all units other than impoundments used to manage blast furnace APC dust/sludge. If dust suppression practices are not effective, or are stopped for any reason, the potential for dust to be released from these units is relatively high because of the large size of the units at some of these facilities (up to 75 acres) and the large number of dry days each year (230 to 270) when APC dust could be released to the atmosphere. If releases occur, there is significant potential for human exposure at nearby residences (15 to 530 meters downwind). The population within 1.6 km (1 mile) of these facilities ranges from 2,000 to 25,000 people.

- Bethlehem/Burns Harbor and Warren practice dust suppression at some of the units used to manage APC dust/sludge. Releases from dry units at these facilities (a total surface area of 9 hectares (21 acres) at Burns Harbor and 1.3 hectares at Warren) could present inhalation risks for residents living as close as 530 and 100 meters from the Burns Harbor and Warren facilities, respectively. A total of 100 people live within 1.6 km (1 mile) of the Burns Harbor plant and 20,000 people live within 1.6 km of the Warren plant, and could be exposed to airborne contaminants released from APC dust/sludge management units that are dry.

- Seven iron and steel production plants (i.e., Shenango, USX/Fairfield, ARMCO, Inland, LTV/West Cleveland, Bethlehem/ Bethlehem, and LTV/Indiana Harbor) do not practice dust suppression at units used to manage APC dust/sludge. Given the large exposed surface areas of these units (0.08 to 140 hectares) and the large number of dry days each year (250 to 270) when APC dust could be released to the air, the potential for releases of contaminants to the air pathway is relatively high at these facilities. Releases of airborne contaminants could pose human health threats to residents living as close as 15 to 400 meters from these facilities. The total population that might be exposed to airborne contaminants within 1.6 km of these facilities ranges from 3,200 to 20,000 people.

Proximity to Sensitive Environments

As discussed in Section 8.3.1 above, 23 of 26 iron production facilities and 21 of 26 steel production facilities are located in or near environments that are vulnerable or environments that have high resource value (see the discussion in Section 8.3.1).

Risk Modeling

Based upon the evaluation of intrinsic hazard and the descriptive analysis of factors that influence risk presented above, and upon a comprehensive review of information on documented damage cases (presented in the next section), EPA has concluded that the potential for blast furnace and steel furnace slag and APC dust/sludge to pose significant risk to human health or the environment, if managed according to current practice, is low at most facilities but moderate to high at others. This conclusion that the risks are low at most facilities is supported by the Agency's modeling results for other mineral processing wastes that appear to pose a greater hazard than the ferrous wastes, as well as the lack of damage cases (as outlined in the next section). Therefore, in accordance with the risk assessment methodology outlined in Chapter 2, the Agency has not conducted a quantitative risk modeling exercise for these wastes. Section 8.3.4 below discusses the basis for the assessment of the hazard of these wastes in more detail.

8.3.3 Damage Cases

The Agency reviewed State and EPA regional files in an effort to document the performance of slag and APC dust/sludge waste management practices at the active iron and steel facilities, as well as at the following inactive facilities:[17]

US Steel (USX)

- National Works, McKeesport, Allegheny County, PA
- West Mifflin Works (Brown's Dump), West Mifflin, Allegheny County, PA
- Taylor Landfill, West Mifflin, Allegheny County, PA
- Vandergrift Plant, Vandergrift, Westmoreland County, PA
- Clairton Works, Clairton, Allegheny County, PA
- Carrie Furnace, Rankin, Allegheny County, PA
- Imperial Works, Oil City, PA
- Homestead (Carrie Furnace), Rankin, PA
- Irvin Plant, West Mifflin, Allegheny County, PA

LTV Steel

- Aliquippa Works (Crows Island/Blacks Run Creek Residual Site) Aliquippa, Beaver County, PA

Bethlehem Steel

- Steelton, PA
- Johnstown, Cambria County, PA
- Riders Disposal Area, East Taylor Township, Cambria County, PA
- Chesterton, IN

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[17] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found documented environmental damages associated with the wastes of concern for only one facility, LTV Steel's Aliquippa Works, in Aliquippa, Pennsylvania.

LTV Steel, Aliquippa, Pennsylvania.

The Jones and Laughlin Steel Corporation (J&L, or LTV Steel) Aliquippa Works, also known as Crow Island, is located in Beaver County, Pennsylvania, along the Ohio River. The Aliquippa Works, no longer an operating facility, was shut down in about 1985.[18] When operational, the Aliquippa facility contained both blast furnace and basic oxygen furnace operations.[19] The Aliquippa facility is located in the flood plain of the Ohio River. The average ground elevation (735 ft Mean Sea Level) is about 15 meters (50 feet) above the normal pool elevation of the Ohio River. At least five private drinking water wells are within 0.8 km (1/2 mile) of an on-site landfill.

Documented environmental impacts have occurred in two general areas of the site. The first area is the Black's Run Landfill, which is lined with basic oxygen furnace slag; leachate from this landfill has entered Black's Run Creek. The second area is the Aliquippa Works facility itself. At least a portion of the facility is underlain by blast furnace slag, which has a thickness of 16 meters (52 feet) in some places.[20] This blast furnace slag is contaminating shallow ground water that seeps into surface water.

The Black's Run area has served as a storage and disposal site for over 40 years. In 1980, J&L commenced operation of a RCRA Subtitle C landfill within the Black's Run site for disposal of certain designated hazardous wastes generated by J&L in the iron- and steel-making processes. The primary hazardous waste disposed at Black's Run was and is air pollution-control dust from electric arc steelmaking furnaces at J&L's Cleveland and Pittsburgh Works.[21,22,23]

The disposal cell was lined with multiple layers: a two foot layer of basic oxygen furnace slag, covered with one and one half feet of low permeability flyash, and topped with a three foot layer of slag. The landfill was constructed on a slope, directing leachate downward to be collected and treated at the 'toe' of the slope.[24]

EPA did not find information on concentrations of metals or other toxic pollutants for either area, but information several conventional water quality parameters was available.

Basic Oxygen Furnace Slag

By 1982, Pennsylvania Department of Environmental Regulation (PADER) investigators found indications that leachate from the landfill was discharging into the East Fork of Black's Run Creek, and that a white precipitate had been deposited on the stream bottom downstream of the landfill. The inspector reported that the leachate was apparently not from the electric furnace dust and sludge, but rather from the slag and ash liner.[25] This white deposit, attributed to the slag liner, was noted in 1987 and 1988 as well.[26,27]

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[18] USEPA, Region III. 1985. Letter to LTV Steel, Aliquippa, Re: Application for Post-Closure Permit, EPA I.D. No. PAD 00 080 5028.

[19] Jones and Laughlin Steel. 1981. Black's Run Disposal Site Facility Description. 8/27/81.

[20] LTV Steel. 1980. Hydrogeologic Investigation of Number 18 Well Ammonia Contamination, prepared by The Chester Engineers. August, 1980.

[21] LTV Steel, Aliquippa. 1980. General public news release on Black's Run Secure Landfill. 11/20/80.

[22] Jones and Laughlin Steel. 1981. Black's Run Disposal Site Facility Description.

[23] LTV Steel, Aliquippa. 1982. Form filled for PADER: Request for Approval to Treat, Store, or Dispose of a Hazardous or Residual Waste Stream. 8/25/82.

[24] PADER. 1982. Bureau of Solid Waste Management Memo, from S. McDougall to V. Luci. Re: Jones and Laughlin Steel Corporation, Aliquippa Works, Blacks Run Disposal Site, RCRA Well Proposal Review, and General Site Comments. 12/29/82.

The landfill was closed in September 1987, because its slag liner did not meet the revised standards for an operating permit. Closure activities involved regrading, capping with a clay/soil layer, and securing the area with a fence.[28] Monitoring wells were installed around the landfill at depths to monitor both the shallow aquifer and a deeper aquifer.[29]

Samples taken in March 1987 show Black's Run Creek upstream of the landfill at a pH of 8.43, and total dissolved solids (TDS) at 597 mg/l. Downstream of the landfill, the pH of Black's Run was elevated to 12.30 and TDS to 1,925 mg/l. Monitoring well sampling on this same date showed a significant increase in pH from the upgradient shallow well at a mean of 7.71 to the downgradient shallow well at a mean of 9.29, exceeding the National Secondary Drinking Water Regulations maximum pH level of 8.5. Analytical data for parameters other than pH and TDS were not contained in the available documents.[30]

In a June 1988 inspection report, the PADER inspector noted that visible impacts to the Black's Run Creek occurred much farther downstream than when they had been first noted several years previously. The inspector found the creek bottom covered with precipitate for approximately 460 meters (500 yards) downstream. The PADER inspector also stated that little aquatic life was evident in the creek from the point where it passed the landfill until well below all the seeps, close to where the stream goes under Route 51. Another inspector in June 1988 found erosion problems on the soil cap of the closed landfill, and an unsatisfactory revegetation status.[31,32,33]

Blast Furnace Slag

As mentioned previously, the Aliquippa Works facility itself was constructed on blast furnace slag fill, which is at least 16 meters (52 feet) thick in some places.[34,35]

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[25] Ibid.

[26] PADER. 1987. Bureau of Waste Management, Hazardous Waste Inspection Report, TSD Facilities. LTV Steel Blacks Run Creek Secure Cell, Aliquippa, Beaver County. 11/6/87.

[27] PADER. 1988. Bureau of Solid Waste Management, General Inspection Form. LTV Steel - Blacks Run Creek Residual Site, Aliquippa, PA. 6/2/88.

[28] PADER. 1990. Personal Communication with C. Spadero.

[29] PADER. 1988. Bureau of Waste Management, Comments on closure of LTV Blacks Run site, Aliquippa. (9/23/86 and 7/1/88.)

[30] LTV Steel. 1987. Letter with attachments to PADER, Re: Black's Run Secure Landfill Groundwater Monitoring Data and Statistical Analysis, Tenth Quarter (1st Quarter, 1987), Aliquippa Works, Aliquippa, PA. 7/24/87.

[31] PADER. 1988. Bureau of Solid Waste Management, General Inspection Form. LTV Steel - Blacks Run Creek Residual Site, Aliquippa, PA. 6/2/88.

[32] PADER. 1988. Bureau of Waste Management, Hazardous Waste Inspection Report, TSD Facilities. LTV Steel Blacks Run Creek Secure Cell, Aliquippa, Beaver County. 6/10/88.

[33] PADER. 1988. Bureau of Waste Management, Comments on closure of LTV Blacks Run site, Aliquippa. (Includes 9/23/86 and 7/1/88.).

[34] LTV Steel. 1980. Hydrogeologic Investigation of Number 18 Well Ammonia Contamination, prepared by The Chester Engineers. 8/80.

[35] LTV Steel. 1988. Letter to USEPA, Region III and PADER, Re: NPDES Permit No. PA 0006114: November, 1988 Monitoring Results. 12/27/88.

In a cover letter for monitoring data submitted by LTV to PADER, LTV discussed elevated pH and TDS values in seep samples, stating that such values "are not unexpected from areas where the slag was placed for fill." Analytical data from these seeps from 1977 through 1985 showed pH values ranging from 12.1 to 13.1, while TDS values ranged from 1370 mg/l to 3508 mg/l.[36]

In a letter to PADER in December 1987, LTV discussed its NPDES violations. LTV reported two outfalls discharging water with pH values of 10.9 and 10.4, exceeding the maximum permitted pH of 9.0. LTV explained that "the fill in the area of the two outfalls is all blast furnace slag. This would cause high pH in rainwater entering the now idled sewers."[37]

LTV's November 1988 NPDES monitoring results submitted to PADER indicated an exceedance of the maximum permitted pH level of 9.0 in an outfall with pH 9.4. LTV again explained that the Aliquippa Works is built on slag fill. LTV noted that since no operating facility uses the sewer of concern, ground water from the slag filled areas was probably infiltrating the sewers and causing the high pH.[38]

8.3.4 Findings Concerning the Hazard Posed by Special Wastes from Ferrous Metals Production

Based upon the detailed examination of the inherent characteristics of iron blast furnace and steel furnace slags and APC dusts/sludges, the management practices that are applied to these wastes, the environmental settings in which the generators of the materials are situated, and the documented environmental damages that have been described above, EPA concludes that these wastes pose a low to moderate risk to human health and the environment.

Blast Furnace and Steel Furnace Slag

Review of the available data on blast furnace and steel furnace slag solid sample and leachate constituent concentrations indicates that only seven constituents are present at concentrations greater than 10 times conservative screening criteria. In blast furnace slag, concentrations of manganese, iron, lead, arsenic, and silver exceed screening criteria by more than a factor of 10. Concentrations of manganese, iron, chromium, thallium, and arsenic in steel furnace slag exceed one or more of the conservative screening criteria by more than a factor of 10. In addition, aqueous extracts of both blast furnace and steel furnace slag are highly alkaline (pH up to 11.7). These exceedances indicate the potential for the slags to pose risks under very conservative, hypothetical exposure conditions. The wastes do not exhibit any of the four characteristics of a hazardous waste, and the actual exposure conditions at the active facilities are not as conducive to human health or environmental damage as those upon which the screening criteria are based. This is largely because the slags consist of large solid fragments that are not readily released and dispersed. This finding leads EPA to conclude that the intrinsic hazard of these slags is low.

Based on a review of the site-specific conditions at 11 facilities, the potential for blast furnace and steel furnace slag to cause significant impacts appears low at most of the active facilities. The potential for significant releases to ground water is often limited by a low net recharge and a large depth to ground water. The potential for significant surface water impacts is limited by the large particle size of the slag (which precludes erosion) as well as the large distances to water bodies, large surface water flow rates, and great downstream distances to potential receptors at many sites. The large particle size of the slag also limits the potential for significant airborne releases. This overall low-risk conclusion is supported by the general lack of documented cases of damage attributable to the slags. Even though the slags have been generated and managed at many sites for several decades, EPA identified only one damage case and that case is associated with an inactive facility under rather unusual conditions (i.e., the slag was used as a liner for a hazardous waste landfill). EPA believes that the management controls and environmental conditions at a few of the active facilities are, in theory, also favorable for contaminant releases to ground and surface water, but no releases are known to have occurred at these sites in the past.

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[36] LTV Steel. 1985. Letter with attachments to PADER, Re: LTV Steel Company, Inc. (Jones and Laughlin Steel, Inc.) Aliquippa Works - Crow Island Site. 8/27/85.

[37] LTV Steel. 1987. Letter to PADER, Bureau of Water Quality, Re: NPDES Permit PA 0006114, Pollution Reduction Report, LTV Steel Co., Beaver County. 12/2/87.

[38] LTV Steel. 1988. Letter to USEPA, Region III and PADER, Re: NPDES Permit No. PA 0006114: November, 1988 Monitoring Results. 12/27/88.

Blast Furnace and Steel Furnace APC Dust/Sludge

Review of the available data on blast furnace and steel furnace APC dust/sludge solid samples and leachate concentrations indicates that a number of constituents are present at concentrations that exceed the conservative screening criteria. Concentrations of 12 constituents in blast furnace APC dust/sludge exceed one or more of the conservative screening criteria by more than a factor of 10. In steel furnace APC dust/sludge, manganese, iron, zinc, lead, selenium, chromium, thallium, and antimony concentrations exceed one or more of the conservative screening criteria by more than a factor of 10. In addition, aqueous extracts of both blast furnace and steel furnace APC dust/sludge are highly alkaline (pH up to 12.5). While releases and exposures are generally not expected to be as large as the hypothetical conditions upon which the screening criteria are based, the dusts/sludges consist of small particles that could be released to the environment if not properly controlled. The available data also indicate that some blast furnace APC dust/sludge at some facilities exhibits the characteristic of EP toxicity, but that steel furnace APC sludge probably is not EP toxic (although the selenium concentration in one sample did exceed the regulatory level by a factor of 1.46). As a result, EPA believes that the intrinsic hazard of these wastes is moderate to high.

Based on an examination of the site-specific conditions at 17 facilities, the current management of blast furnace and steel furnace APC dust/sludge poses a low threat at some facilities but a moderate to high threat at others. In general, the potential for the dust/sludge to cause significant ground-water impacts is limited at most sites that manage the waste in a dry form (in stockpiles, landfills, waste piles, etc.) because of the low net recharge, depth to ground water, and/or distance to potential receptors. When managed in impoundments, however, there is a considerably greater potential for the dust/sludge contaminants to migrate into ground water. EPA believes that the potential for dust/sludge contamination to migrate into surface water is high at 13 of the facilities because of the wastes's small particle size, a lack of engineered controls to limit releases, and a close proximity to surface water bodies. However, contaminants entering rivers near all but four of these facilities are likely to be readily assimilated by the rivers' large flow. Considering the susceptibility of the dust/sludge to wind erosion, the exposed surface area of waste management units, the lack of dust suppression controls, atmospheric conditions, and population distributions, there is also a relatively high potential for airborne releases and exposures at seven facilities. Despite these theoretical conclusions about potential hazards, EPA did not identify a single case of environmental degradation that can be attributed to the dust/sludge. Therefore, considering the site-specific conditions together with the lack of damage cases, EPA concludes that the dust/sludge poses an overall moderate risk.

8.4 Existing Federal and State Waste Management Controls

8.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations" which provide the basis for the minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of mineral processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines, based on the best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). These limitations do not apply to non-point sources, such as run-off from slag piles, or impoundments containing APC sludges and dusts. BPT effluent limitations (40 CFR 420.32(a)) for discharges of wastewater from iron blast furnace slags include:

Pollutant	Daily Maximum	Monthly Average
Ammonia	0.161 Kg/kkg	0.0537 mg/l
Cyanide	0.0234 mg/l	0.00782 mg/l
Phenols	0.00626 mg/l	0.00210 mg/l

For BAT, the following effluent limitations, found at 40 CFR 420.33(a), apply to discharges from iron blast furnaces:

Pollutant	Daily Maximum	Monthly Average
Ammonia	1.29 mg/l	0.429 mg/l
Cyanide	0.469 mg/l	0.156 mg/l
Phenols	0.0624 mg/l	0.0208 mg/l

The discharge of wastewater pollutants from any new source of iron blast furnace slag may not exceed the following (40 CFR 420.34(a)):

Pollutant	Daily Maximum	Monthly Average
Ammonia	0.00876 mg/l	0.00292 mg/l
Cyanide	0.000584 mg/l	0.000292 mg/l
Phenols	0.0000584 mg/l	0.0000292 mg/l
Lead	0.000263 mg/l	0.0000876 mg/l
Zinc	0.00394 mg/l	0.000131 mg/l

EPA has also established BPT and BAT effluent limitations resulting from steelmaking operations conducted in basic oxygen and open hearth furnaces. BPT effluent limitations allow no discharge from semi-wet BOF steelmaking. BPT limitations for steel-making operations for which wastewater discharges are allowed include (40 CFR 420.42(b),(c)):

BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION		
Pollutant	**Daily Maximum**	**Monthly Average**
Total Suspended Solids	0.0312 Kg/kkg	0.0104 Kg/kkg
pH	6-9	6-9

<table>
<tr><th colspan="3">BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION AND
OPEN HEARTH FURNACE - WET</th></tr>
<tr><th>Pollutant</th><th>Daily Maximum</th><th>Monthly Average</th></tr>
<tr><td>Total Suspended Solids</td><td>0.0687 Kg/kkg</td><td>0.0229 Kg/kkg</td></tr>
<tr><td>pH</td><td>6-9</td><td>6-9</td></tr>
</table>

BAT effluent limitations allow no discharge from semi-wet BOF steelmaking (40 CFR 420.43(a)). BAT limits for wastewater discharges from other processes include (40 CFR 420.43 (b),(c)):

<table>
<tr><th colspan="3">BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION</th></tr>
<tr><th>Pollutant</th><th>Daily Maximum</th><th>Monthly Average</th></tr>
<tr><td>Lead</td><td>0.000188 Kg/kkg</td><td>0.0000626 Kg/kkg</td></tr>
<tr><td>Zinc</td><td>0.000282 Kg/kkg</td><td>0.0000939 Kg/kkg</td></tr>
</table>

<table>
<tr><th colspan="3">BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION AND
OPEN HEARTH FURNACE - WET</th></tr>
<tr><th>Pollutant</th><th>Daily Maximum</th><th>Monthly Average</th></tr>
<tr><td>Lead</td><td>0.000413 Kg/kkg</td><td>0.000138 Kg/kkg</td></tr>
<tr><td>Zinc</td><td>0.000620 Kg/kkg</td><td>0.000207 Kg/kkg</td></tr>
</table>

New source standards for discharges include (40 CFR 420.44 (b),(c)):

<table>
<tr><th colspan="3">BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION</th></tr>
<tr><th>Pollutant</th><th>Daily Maximum</th><th>Monthly Average</th></tr>
<tr><td>Total Suspended Solids</td><td>0.0146 Kg/kkg</td><td>0.00522 Kg/kkg</td></tr>
<tr><td>Lead</td><td>0.000188 Kg/kkg</td><td>0.0000626 Kg/kkg</td></tr>
<tr><td>Zinc</td><td>0.000282 Kg/kkg</td><td>0.0000939 Kg/kkg</td></tr>
<tr><td>pH</td><td>6-9</td><td>6-9</td></tr>
</table>

BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION AND OPEN HEARTH FURNACE - WET

Pollutant	Daily Maximum	Monthly Average
Total Suspended Solids	0.0321 Kg/kkg	0.0115 Kg/kkg
Lead	0.000413 Kg/kkg	0.000138 Kg/kkg
Zinc	0.000620 Kg/kkg	0.000207 Kg/kkg
pH	6-9	6-9

8.4.2 State Regulation

The 28 facilities generating blast furnaces slag, steel furnace slag, blast furnace APC dust and sludge, and/or steel furnace APC dust and sludge are located in ten states, including Alabama, Illinois, Indiana, Kentucky, Maryland, Michigan, Ohio, Pennsylvania, Utah, and West Virginia. Five of these states, Indiana, Kentucky, Ohio, Pennsylvania, and Utah, were selected for detailed review for the purposes of this report (see Chapter 2 for a discussion of the methodology used to select states for detailed study). Within the five study states, the majority of facilities are located in Ohio (seven), Pennsylvania (six), and Indiana (four). Based on the distribution of facilities within the five study states, state-level regulation of ferrous metal production facility wastes is of particular interest in the States of Ohio and Pennsylvania.

Each of the ten states with one or more ferrous metal production facilities have adopted the federal Mining Waste Exclusion and therefore do not regulate any of the four special wastes from ferrous metal production as hazardous wastes. Three of the five study states, Ohio, Indiana, and Utah, do not regulate iron or steel slag within their solid waste regulations. None of the states appear to regulate slag stored on-site for eventual recycling or reprocessing. APC dust and sludge may be shipped to permitted landfills, although this is not regularly required by state regulation. Limited requirements are imposed on dust and sludge disposed on-site. Requirements for NPDES permits and run-on/run-off controls vary by state and by facility in each state. Similarly, requirements for fugitive dust controls vary by state regulation and facility location. In contrast to the limited nature of current regulatory efforts, Ohio and Indiana recently promulgated new solid waste regulations; Kentucky is finalizing new regulations; Pennsylvania recently proposed new residual waste regulations; and Utah recently passed new ground-water legislation. The increasing regulation of ferrous wastes in each of these states could significantly affect the management of ferrous wastes, particularly APC dust and sludge.

Seven ferrous metal production facilities are located in Ohio. The Ohio Solid Waste Disposal Regulations state that slag is not a waste. The re-use of slag, however, may be subject to certain requirements. Ohio does regulate APC dust and sludge as a solid waste. Facilities generating APC dust and sludge must either obtain a permit to dispose of this waste on-site or ship the waste to a permitted landfill off-site. According to state officials, only one of the seven facilities in the state has a permit for on-site disposal while the remaining facilities either store the dust and sludge indefinitely for recycling or ship it off-site for disposal. State officials were not able to provide details on the final disposition of much of the waste. Regulatory controls of these wastes, until the recent promulgation of new solid waste regulations, appear to have been limited. The recently amended regulations, however, require owners and operators of all landfills, including on-site APC dust and sludge landfills, to apply for a permit and meet a variety of technical criteria (e.g., removal of free liquids, establishment of ground-water monitoring, placement of a final cap, provision of financial assurance). Finally, although NPDES permits are required for discharges to waters of the state and permits are required for landfills with fugitive dust emissions, Ohio does not appear to apply these requirements to ferrous slag piles or surface impoundments.

Ferrous metal production slags and APC dust and sludges are not regulated as either hazardous or solid wastes by Pennsylvania. Instead, the state currently regulates ferrous wastes as "residual wastes." A proposed rule regulating residual wastes would require a substantial expansion in the scope of the management controls for slag and APC dust and sludge. The current residuals rule imposes only limited permitting requirements. For instance, although waste piles used for permanent disposal must be permitted under current state residuals regulations, Pennsylvania effectively has not implemented this requirement for slag piles because of disagreements with industry on the status (i.e., storage versus disposal) of the waste. Similarly, the state applies surface water and air (i.e., fugitive dust control) requirements on ferrous metal production waste management activities on a case-by-case basis and generally in response to complaints or evidence of contamination only. Although the proposed rule would impose notably more stringent environmental controls on the management of ferrous wastes, the final status of these wastes and the exact nature of additional environmental controls will depend on the final rule.

Indiana does not regulate the "legitimate use of iron and steelmaking slags..." Indiana classifies APC dust and sludge, however, as a special waste and requires that waste shipped off-site be sent to a designated landfill meeting the technical criteria for special wastes. Owners and operators disposing of APC dust and sludge on-site were not required to meet special landfill standards until the state modified its regulations in 1989. Three of the four facilities in the state have submitted permit applications to continue on-site disposal, but it is not yet clear what kinds of technical requirements the state may impose in response to these applications. Surface water and air discharge controls are addressed by the state on a facility-specific basis and generally have been limited in scope. The extent of waste management requirements for ferrous wastes remains somewhat unclear because the state's regulatory program implementation efforts have not been completed.

One ferrous metal production facility is located in Kentucky. Kentucky requires some environmental controls (e.g., maintaining a temporary cover, run-on/run-off controls, and drainage ditches) for on-site slag disposal piles, but these requirements do not apply to slag that is reprocessed or sold. The state also requires that the "residential" landfill to which the APC dust and sludge is shipped meet ground-water monitoring criteria. Kentucky imposes effluent discharge limits on all iron and steel plant discharges, and imposes extensive fugitive dust emission controls on slag management activities including watering of slag as it is generated, "quenching" of trucks transporting slag, and transportation of slag on oiled roads. Kentucky recently finalized its solid waste regulations and may impose more stringent environmental controls on the management of slags and APC dusts and sludges at the ferrous facility, although the extent of the requirements cannot be predicted until the regulations are implemented.

The state of Utah also has one ferrous metal production facility. In contrast to Kentucky, however, Utah does not address either ferrous metal production slags or APC dusts and sludges under its solid waste regulations. Utah recently enacted new ground-water legislation which mandates that all ground-water discharges be permitted, though the state has not yet issued such permits. Moreover, although Utah has particulate matter air emissions regulations, it is not clear to what extent controls are required for ferrous waste management (in particular, slag) at this facility.

In summary, ten states generate ferrous metal production slags and/or APC dust and sludges, of which five states were studied in detail for this report. The five study states regulate ferrous metal production wastes similarly in a number of respects. For the most part, iron and steel slag management is currently subject to limited solid waste regulation in these states, although in some cases waste slag is disposed of in a permitted landfill. Although the management and disposal of APC dust and sludge has also been subject to limited regulatory controls, these wastes are landfilled by facilities in several states and thus subject to all pertinent regulations governing landfills in those states. Moreover, APC dust and sludge, as a rule, is regulated more frequently than slag by the five study states. Finally, four of the five study states recently published final or proposed waste regulations, while the fifth state recently enacted new ground-water protection legislation, all of which could affect significantly the kinds and stringency of environmental controls imposed by the states on ferrous metal production waste management and disposal activities.

8.5 Waste Management Alternatives and Potential Utilization

Iron Blast Furnace Slag

As discussed above, EPA does not believe that iron blast furnace slag exhibits any of the four characteristics of hazardous waste (corrosivity, reactivity, ignitability, or EP toxicity). Consequently, the issue of how iron producers might modify their operations, waste management practices, or be stimulated to develop alternative uses for iron slag in response to prospective hazardous waste regulation under RCRA Subtitle C is moot. Any such operational changes that are currently contemplated by facility operators will therefore not be affected by EPA's actions, and hence, are beyond the scope of this Report to Congress. Nonetheless, in the following paragraphs, the Agency provides a brief summary of current and potential areas of utilization.

In 1988, nearly 18.8 million metric tons of iron blast furnace slag were generated by 26 U.S. iron processing facilities.[39] On-site accumulation at the 26 facilities ranges from 0 to 10 million cubic meters (0 to 13 million cubic yards), with a total accumulation of over 14.6 million cubic meters in active waste management units.[40] The facility which has accumulated 10 million cubic meters of slag, Inland Steel in East Chicago, is placing it in Lake Michigan in order to create land on which additional waste can be disposed.[41] Surveys of slag processors nationwide indicate that 14.4 million metric tons of slag were sold and/or used in the United States in 1988 at an average price of $6.97 per ton.[42] Some of this slag was retrieved from slag piles at abandoned facilities.

According to a Bureau of Mines survey, 90 percent (16.9 million metric tons) of the iron blast furnace slag utilized in 1988 was air-cooled. Air-cooled slag was sold at an average price of $4.87 per ton, ranging from an average of $3.29 when sold for use as fill to an average of $9.87 when sold as material for built-up and shingle roofing. Distribution of air-cooled slag among its various applications is shown in Exhibit 8-11.

Exhibit 8-11
Uses of Air-Cooled Iron Blast Furnace Slag[43]

Road base	57%
Concrete aggregate	12%
Fill	10%
Asphaltic concrete aggregate	7%
Railroad ballast, mineral wool, concrete products, glass manufacture, sewage treatment, roofing, and soil conditioning	14%

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[39] Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[40] Ibid.

[41] Personal communication, Judith F. Owens, Physical Scientist, U.S. Bureau of Mines, Branch of Ferrous Metals, April 24, 1990.

[42] Judith F. Owens, "Slag-Iron and Steel," Minerals Yearbook-1988, U.S. Department of the Interior, Bureau of Mines, 1988, p. 2.

[43] Ibid. p.5

The remaining 10 percent (1.8 million metric tons) of iron blast furnace slag utilized in 1988 was comprised of expanded slag, which is primarily used as a light-weight concrete aggregate, and granulated (water-cooled) slag, most of which is used in the manufacture of Portland cement and other cementitious materials. Of the iron blast furnace slag generated in the U.S., the Bureau of Mines indicates that nearly all of it is eventually utilized.[44]

In the future, most primary iron producers in the U.S. are expected to modernize their blast furnaces and install slag granulation facilities. If such a change does occur, it is likely to result in more slag being used to manufacture Portland cement, and less slag being utilized as aggregate or road base. There has also been some speculation about using iron blast furnace slag to stabilize low-level radioactive wastes, and also in the manufacture of a ceramic-matrix composite material used in interior building applications.[45]

Iron Blast Furnace Air Pollution Control (APC) Dust/Sludge

As discussed above, EPA sampling data indicate that some APC dust/sludge from iron blast furnaces may exhibit the hazardous waste characteristic of EP toxicity at some facilities. Accordingly, the Agency has conducted an intensive literature review of potential waste management alternatives and potential areas of utilization, as described in Chapter 2. The major finding of this effort is that very little has been reported in the published literature addressing these topics, suggesting that aside from recycling, there are few established alternatives for the management of this material.

EPA has been able to establish that in 1988, iron producers reported that approximately 447,000 metric tons (36.3 percent) of the iron blast furnace APC dust/sludge was recycled to the beneficiation processes via the sinter plant and blast furnace, 750,000 metric tons (60.9 percent) was disposed of, and 34,000 metric tons (2.8 percent) was sold or sent off-site for further metal recovery.[46] It is believed that at least some of the APC dust/sludge which was sold or sent off-site, was probably used by zinc producers as a source of zinc.

Steel Furnace Slag

As discussed above, EPA does not expect that steel furnace slag would exhibit any of the four characteristics of hazardous waste (corrosivity, reactivity, ignitability, or EP toxicity). Consequently, the issue of how steel producers might modify their operations, waste management practices, or be stimulated to develop alternative uses for steel furnace slag in response to prospective hazardous waste regulation is not applicable. Any such operational changes that are currently contemplated by facility operators will therefore not be affected by EPA's actions, and hence, are beyond the scope of this Report to Congress. Nonetheless, in the following paragraphs, the Agency provides a brief summary of current and potential areas of steel furnace slag utilization.

In 1988, 24 of the 26 steel mills in the U.S. generated over 13.2 million metric tons of steel slag.[47] The primary management practices for steel furnace slag are recycling it to the blast furnace and processing it for use as an aggregate. In 1988, U.S. steel mills recycled approximately 1.8 million metric tons of steel slag.[48] A nationwide survey of slag processors conducted by the Bureau of Mines indicated that over 5.1 million metric tons of steel furnace slag was sold or used in the U.S. in 1988 at an average price of $3.16 per ton, ranging from an average of $2.44 when sold for railroad ballast to $4.55 when sold for asphaltic concrete aggregate.[49] The distribution of steel furnace slag among its various applications in 1988 is shown in Exhibit

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[44] Ibid., p. 2.

[45] Personal communication, Judith F. Owens.

[46] Company responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[47] Production statistics for two facilities are confidential and not included in this total.

[48] Judith F. Owens, "Slag-Iron and Steel," Minerals Yearbook-1988, U.S. Department of the Interior, Bureau of Mines, 1988, p. 2.

[49] Ibid., p. 13.

8-12. The remaining 6.3 million metric tons of steel furnace slag was presumably stockpiled at either the generating facilities or at the slag processing facilities.

Eleven years of Canadian testing and evaluation of 18 bituminous test sections of a major urban freeway showed that the most suitable mixtures for highways with high speed and heavy traffic are those containing steel furnace slag or traprock for course and fine aggregates. Findings such as this one may lead, in the future, to an expanding market for utilization of steel furnace slag as asphaltic concrete aggregate.[50]

Steel Furnace Air Pollution Control (APC) Dust/Sludge

As discussed above, EPA sampling data indicate that APC dust/sludge from steel furnaces may exhibit the hazardous characteristic of EP toxicity at some facilities. Accordingly, the Agency has conducted an intensive literature review of potential waste management alternatives and potential areas of utilization, as described in Chapter 2. The major finding of this effort is that very little has been reported in the published literature addressing these topics, suggesting that aside from recycling, there are few established alternatives for the management of this material.

EPA has been able to establish that in 1988, steel producers reported that approximately 57,700 metric tons (4 percent) of the APC dust/sludge was recycled to the beneficiation processes via the sinter plant and blast furnace, 646,000 metric tons (44.2 percent) was disposed of, and 757,500 metric tons (51.8 percent) was sold or sent off-site for further metal recovery.[51] It is believed that the APC dust/sludge that was sold or sent off-site was probably used by zinc producers as a source of zinc. It may also be that not much of the dust/sludge is recycled because of the presence of zinc and lead, both of which can cause problems in steel production.

Exhibit 8-12
Primary Uses of Steel Furnace Slag[52]

Road base	46%
Fill	25%
Asphaltic concrete aggregate	11%
Railroad ballast, ice control, soil conditioning	18%

8.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly

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[50] K.K. Tam, R. Raciborski, and D.F. Lynch, Ministry of Transportation of Ontario, Canada, "11 Years Performance of 18 Bituminous Test Sections on a Major Urban Freeway," prepared for presentation at the 1989 Transportation Research Board Annual Conference, January 22-26, 1989, Washington, D.C.

[51] Company responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[52] Ibid.

Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C, or if land disposal restrictions had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed by ferrous metal producers under different regulatory scenarios, developed the cost implications of requiring changes in existing waste management practices, and predicted the ultimate impacts of increased waste management costs associated with changes in the regulatory environment faced by iron and steel facility operators.

8.6.1 Regulatory Scenarios and Required Management Practices

Because the available data indicated that iron blast furnace slag and steel furnace slag pose low risks and do not exhibit any of the characteristics of hazardous waste, the issue of how waste management costs might change if Subtitle C regulatory requirements were applied and what impacts such costs might impose upon affected facilities is moot, and is not considered further in this report.

In contrast, based upon the information presented above, EPA concluded that both iron and steel APC dust/sludge could be subjected to regulation under Subtitle C absent the Mining Waste Exclusion. Waste composition data collected by EPA and submitted by facility operators indicate that these materials may exhibit characteristics of hazardous waste at some facilities, and the analysis of potential risk presented above demonstrates that the physical form and chemical characteristics of these materials, the management practices that are employed, and environmental settings in which waste management occurs could, in combination, impose risk to human health and the environment. Accordingly, the Agency has estimated the costs associated with such regulation, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D" as previously introduced in Chapter 2, and as described in specific detail below.

In conducting its cost analysis, EPA has adopted the approach that only those iron and steel facilities that actually were sampled and whose waste(s) exhibited hazardous characteristics would be analyzed for regulatory compliance. The Agency assumed that APC dust/sludge at facilities that were not sampled would not exhibit the characteristic of EP toxicity; this assumption is based on the fact that wastes from the majority of the facilities sampled (and the great majority of the total number of samples) did not exhibit EP toxicity, and no damage cases involving these wastes were found (See Section 8.3.3.). The Agency's cost and impact analysis is therefore limited to five facilities: three facilities with potentially toxic APC residue from iron blast furnace operations and two facilities with potentially toxic APC residue from steelmaking operations. APC dust/sludge from these operations exhibited EP toxicity for selenium and/or lead.

Subtitle C

Under Subtitle C standards, generators of hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because the APC dusts and sludges are solid, non-combustible materials, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed of in waste piles, EPA has assumed that the ultimate disposition of APC dust/ sludge would be in Subtitle C landfills that meet the minimum technology standards specified at 40 CFR 264. EPA has assumed that the affected facilities would continue to internally recycle the same quantity of dust/sludge as they do currently. The Agency has, however, assumed that the affected facilities would not continue to dispose their wastes off-site if the cost is higher than operating an on-site disposal landfill. The Agency has assumed that, in addition to the disposal units, the affected facilities would also construct a temporary storage waste pile (with capacity of one week's waste generation) that would enable the operators to send the dust/sludge to either on-site or recycling operations efficiently. This assumption reflects current practice, which often includes management in waste piles.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-Minus is the facility-specific application of requirements based on potential risk from the hazardous special waste. Under the C-Minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating ground-water resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) will be necessary to protect human health and the environment. One of the five facilities of concern, US Steel/Fairless Hills, was determined to have a high potential to contaminate ground-water resources; the other four were determined to have a moderate groundwater contamination potential. The Fairless Hills facility, however, recycles its APC residue to the sinter/blast furnace operation and, therefore, operates no on-site disposal units; this mode of operation would continue under C-Minus. A second of the five facilities of concern, Sharon Steel's Farrell facility, currently disposes off-site; EPA's cost comparison analysis indicates that, under the C-Minus scenario, the facility would be likely to build an on-site disposal landfill. The remaining three facilities, all of moderate risk, dispose on-site in landfills or impoundments, none of which have liners that conform to the standards of this regulatory scenario. Therefore, each is assumed to build new disposal landfills containing a three foot clay liner and a protective fill layer. Each must also incorporate run-on/run-off controls and perform groundwater monitoring. In addition, the disposal units must undergo formal closure, including a cap of topsoil and grass over a composite liner. Post-closure care must be performed (e.g., leachate collection and treatment, cap and run-on/run-off control maintenance, and continued groundwater monitoring) for a 30 year period.

Subtitle D-Plus

As under both Subtitle C scenarios, facility operators would, under the Subtitle D-Plus scenario, be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to ground water increases. The four facilities which dispose on-site (i.e., the Fairless Hills facility will continue to recycle) are assumed to build new disposal landfills with three foot clay liners and a protective fill layer. Each must incorporate run-on/run-off controls and perform groundwater monitoring. In addition, the disposal units must undergo formal closure, including a cap of topsoil and grass over a composite liner. Post-closure care must be performed (e.g., leachate collection and treatment, cap and run-on/run-off control maintenance, and continued groundwater monitoring) for a period of 30 years.

8.6.2 Cost Impact Assessment Results

Iron Blast Furnace APC Dust/Sludge

Regulatory compliance cost estimates for iron blast furnace APC dust/sludge are displayed in Exhibit 8-13. Of the 26 facilities operating iron blast furnaces in the ferrous metals production sector, only three are assumed to generate hazardous APC dust/sludge and, therefore, incur costs under the Subtitle C scenario: U.S. Steel at Fairless Hills, Pennsylvania; Bethlehem Steel at Sparrows Point, Maryland; and LTV Steel at East Cleveland, Ohio. Under the Subtitle C regulatory scenario, the annualized regulatory compliance costs would, respectively, be $68,000, $10.6 million, and $3.5 million greater than baseline waste management costs (76, 16, and 7 times larger than baseline costs, respectively). With the exception of the facility in Fairless Hills, the bulk of the compliance costs would be devoted to new capital expenditures. Specifically, the increase in annualized new capital expenditures for each facility would be $33,700 at Fairless Hills, $8.3 million at Sparrows Point, and $2.6 million at East Cleveland; increases in capital expenditures account for approximately 77 percent of the total annualized compliance costs for the sector. The majority of the prospective cost impact is attributable to the design and construction of the large Subtitle C landfills that would be required to manage this waste. The Fairless Hills facility has such low disposal costs because it utilizes (recycles) all of its air pollution control (APC) dust, so that its compliance activities would consist only of building an APC dust storage area (concrete pad) rather than a far more costly Subtitle C disposal landfill.

Under the facility specific risk-related requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about half of those under the full Subtitle C scenario. The annualized regulatory compliance costs for the Sparrows Point and East Cleveland facilities would be $4.6 and $1.6 million greater, respectively, than the baseline waste management costs (7 and 3 times larger than baseline). The cost savings of the Subtitle C-Minus scenario compliance over full Subtitle C costs result primarily from needing fewer liners and a less elaborate leachate collection system for the disposal landfill; capital costs are nearly 60 percent less under this scenario. Annualized compliance capital, however, continues to drive total costs, with capital costs making up approximately 68 percent of the total. The Subtitle C-Minus compliance costs for the Fairless facility would be nearly identical to its Subtitle C costs, since the technical requirements for a temporary storage area are the same under both scenarios.

Costs under Subtitle D-plus are expected to be virtually identical to those under Subtitle C-minus (different permit costs at the Fairless Hills facility are the only cost difference in the sector), as management practices are the same.

Steel Furnace APC Dust/Sludge

Regulatory compliance cost estimates for steel furnace APC dust/sludge are displayed in Exhibit 8-14. Of the 26 facilities operating steel furnaces in the ferrous metals sector, only two are assumed to generate hazardous waste and, therefore, incur costs under the Subtitle C scenario: U.S. Steel at Lorain, Ohio, and Sharon Steel at Farrell, Pennsylvania. Under the Subtitle C regulatory scenario, the annualized regulatory compliance costs would be $3.3 million and $2.3 million greater than the baseline waste management costs (9 and 3 times the baseline cost, respectively). The bulk of the annual compliance costs would be devoted to new capital expenditures; about 75 percent of the total cost is annualized capital costs, approximately $4.1 million for the two facilities combined.

Under the facility specific risk-based requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about 40 percent less than full Subtitle C costs. The annualized regulatory compliance costs for the Lorain and Farrell facilities would be $1.6 and 0.94 million greater than the baseline waste management costs, respectively (5 and 2 times larger than baseline). The cost advantage over the full Subtitle C regulations results primarily from needing fewer liners and a less elaborate leachate collection system for the disposal landfill.

Exhibit 8-13
Compliance Cost Analysis Results for Management of APC Dust/Sludge from Iron Blast Furnaces[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
LTV Steel - East Cleveland, OH	609	3,489	17,245	2,573	1,625	6,748	1,007	1,625	6,748	1,007
Bethlehem Steel - Sparrows Point, MD	692	10,591	55,852	8,334	4,626	22,013	3,285	4,626	22,013	3,285
U.S. Steel - Fairless Hills, PA	1	68	226	34	68	226	34	60	226	34
Total:	1,302	14,148	73,323	10,941	6,318	28,987	4,325	6,310	28,987	4,325
Average:	434	4,716	24,441	3,647	2,106	9,662	1,442	2,103	9,662	1,442

Costs have been estimated only for facilities for which sampling data indicate that the waste would exhibit a RCRA hazardous waste characteristic.

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Exhibit 8-14
Compliance Cost Analysis Results for Management of APC Dust/Sludge from Steel (BOF & OHF) Furnaces[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Sharon Steel - East Cleveland, OH	963	2,342	12,993	1,939	936	5,100	761	936	5,100	761
U.S. Steel - Lorain, OH	413	3,341	14,717	2,196	1,680	5,365	801	1,680	5,365	801
Total:	1,376	5,683	27,710	4,135	2,616	10,465	1,562	2,616	10,465	1,562
Average:	688	2,841	13,855	2,067	1,308	5,232	781	1,308	5,232	781

Costs have been estimated only for facilities for which sampling data indicate that the waste would exhibit a RCRA hazardous waste characteristic.

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Costs under Subtitle D-Plus re expected to be virtually identical to those under Subtitle C-Minus, as management practices are the same and no facilities are in low risk areas, the one condition that allows for differential landfill design and operating standards for the C-Minus and D-Plus scenarios.

8.6.3 Financial and Economic Impact Assessment

In order to evaluate the ability of the affected facilities to bear these estimated regulatory compliance costs, EPA conducted an impact assessment which consisted of three steps. First, the Agency compared the estimated compliance costs to the financial strength of each facility, to assess the relative magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. EPA also conducted a qualitative evaluation of the salient market factors which affect the competitive position of the iron and steel producers, in order to determine whether compliance costs could be passed on to labor, suppliers of raw materials, or consumers. Finally, the Agency combined the results of the first two steps to predict the net compliance-related economic impacts which would be experienced by the facilities being evaluated. The methods and assumptions used in this analysis are described in Chapter 2 and in a Appendices E-3 and E-4 to this report.

Financial Ratio Analysis

Iron Blast Furnace APC Dust/Sludge

Based on ratio analysis, EPA expects regulation under Subtitle C to have no significant impacts on the Fairless Hills facility, because its recycling operations circumvent the need for protective disposal operations. The impacts on the East Cleveland and Sparrows Point facilities, while not highly significant, are potentially significant; the Agency, therefore, has considered other factors such as market strength and ability to pass through costs. The financial ratios, as seen in Exhibit 8-15, are comparisons of annualized compliance costs to value of shipments and to total value added, and annualized compliance capital to annual sustaining capital investments; generally these ratios for the affected facilities fall within the one to five percent range.

The magnitude of financial impacts under Subtitle C-Minus and, identically, D-Plus regulation would be substantially less, though similar in distribution to those under full Subtitle C. For example, compliance cost as a percent of value added at the Sparrows point facility (the operation with the greatest impacts), falls from 4.2 percent under Subtitle C to 2.4 percent under the Subtitle C-Minus and D-Plus scenarios.

Steel Furnace APC Dust/Sludge

EPA believes that regulation under any regulatory scenario would have only marginal impacts on either facility generating steel furnace APC dust/sludge, as seen in Exhibit 8-16. Annual compliance costs as a percentage of either value of shipments or value added are less than one percent, indicating an absence of potentially significant impacts. Annualized compliance costs as a percentage of annual sustaining capital investments, typically a high ratio in affected sectors, is only 2-3 percent, even under full Subtitle C controls. For C-Minus and D-Plus scenarios this ratio is around one percent.

Market Factor Analysis

General Competitive Position

There have been extensive structural changes in the U.S. ferrous metals mining and processing industry since the recession of the early 1980s. Domestic producers have made a number of changes in the 1980's to make the overall iron and steel industry competitive on a worldwide basis. These included several steps:

1. Closure of high-cost mining operations and rationalization of iron ore production to a point where generally lower cost capacity is maintained;

Exhibit 8-15
Significance of Regulatory Compliance Costs for Management of APC Dust/Sludge from Iron Blast Furnaces[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
LTV Steel - East Cleveland, OH	1.0%	2.6%	2.6%
Bethlehem Steel - Sparrows Point, MD	1.6%	4.2%	4.4%
U.S. Steel - Fairless Hills, PA	0.0%	0.1%	0.0%
Subtitle C-Minus			
LTV Steel - East Cleveland, OH	0.5%	1.2%	1.0%
Bethlehem Steel - Sparrows Point, MD	0.9%	2.4%	2.3%
U.S. Steel - Fairless Hills, PA	0.0%	0.1%	0.0%
Subtitle D-Plus			
LTV Steel - East Cleveland, OH	0.5%	1.2%	1.0%
Bethlehem Steel - Sparrows Point, MD	0.9%	2.4%	2.3%
U.S. Steel - Fairless Hills, PA	0.0%	0.1%	0.0%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Costs and impacts have been estimated for only those facilities for which sampling data indicate that the waste exhibits a RCRA hazardous waste characteristic.

Exhibit 8-16
Significance of Regulatory Compliance Costs for Management of APC Dust/Sludge from Steel (BOF & OHF) Furnaces(a)

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Sharon Steel - Farrell, PA	0.4%	0.7%	2.9%
U.S. Steel - Lorain, OH	0.3%	0.6%	1.9%
Subtitle C-Minus			
Sharon Steel - Farrell, PA	0.1%	0.3%	1.1%
U.S. Steel - Lorain, OH	0.2%	0.3%	0.7%
Subtitle D-Plus			
Sharon Steel - Farrell, PA	0.1%	0.3%	1.1%
U.S. Steel - Lorain, OH	0.2%	0.3%	0.7%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Costs and impacts have been estimated for only those facilities for which sampling data indicate that the waste exhibits a RCRA hazardous waste characteristic.

2. Substantial capital investment at remaining facilities to lower costs per iron unit to a point at which domestically produced ore is competitive with ore delivered from oversees; and
3. Investments in iron and steel production process improvements at several mills throughout the U.S.

These changes in the U.S. steel industry structure have allowed the U.S. producers to move from the upper end to the middle end of the supply curve on a worldwide basis.

Potential for Compliance Cost Pass-Through

Labor Markets. Imposing substantially lower wages to counteract compliance costs is not a likely scenario in the ferrous metals industry. There have already been significant wage and benefit concessions and movement in the opposite direction with regard to wages is likely over the next few years.

Raw Material Supply Markets. As many of the U.S. mine supplies have become more cost-competitive, the possibilities of importing lower cost iron ore are declining. Also, the steel companies are partially integrated into ore production and are unlikely to achieve cost savings by ore price rollbacks or mine closures. The mines do provide a depletion allowance which can partially offset any imported ore price savings.

Higher Prices. The possibility of passing along higher prices in the steel industry is rather limited. The ferrous metals market is a world market and, therefore, U.S. prices must be in line with world prices. There are many producers of foreign steel with equal or lower costs than those of the U.S.; substantial price increases could therefore lead to increased imports. More importantly, EPA's data and analysis suggests that only five of the 28 ferrous metals facilities that produce iron and steel would experience increases in waste management costs in the absence of the Mining Waste Exclusion. It is extremely unlikely that these five facilities could successfully pass through compliance costs to domestic consumers given the structure of domestic and global iron and steel markets.

Evaluation of Cost/Economic Impacts

Only two of 28 facilities that generate iron/steel APC dust/sludge would face potentially significant economic impacts under any regulatory scenario. For the two affected facilities, however, the impacts would probably be marginally significant if operators continue to manage the material as a waste (i.e., not recycling to the sinter/smelter operation). The remaining 26 facilities in the primary ferrous metals processing sector will probably not suffer significant impacts if any of the four special wastes (i.e., including slag) generated within the ferrous metals sector were to be removed from the Mining Waste Exclusion. EPA emphasizes, however, that these results are based upon limited waste characterization data; if additional facilities that were not sampled generate EP toxic waste(s), then the costs and impacts predicted here would be underestimates of the true magnitude of regulatory impacts.

Due to the international nature of the market for ferrous metals, U.S. producers would be unlikely to be able to raise prices enough to pass through compliance costs. The Sparrows Point facility might be able to use feedstock cost advantages (related to its coastal location, allowing for lower feedstock transportation costs through use of ocean transport) to recover compliance costs, though recent losses across the industry as a whole have left most facilities with very narrow profit margins. The East Cleveland facility, with its owner/operator (LTV Steel) already in financial difficulties (i.e., having filed for bankruptcy), would be hard pressed to absorb additional regulatory compliance costs and raise new capital for compliance-related investments. The Agency points out, however, that recycling of the waste at these facilities, if technically feasible (at least ten generators of iron blast furnace APC residue recycle all or some of the waste to sinter/smelter operations), would result in neither facility incurring any significant impacts under any regulatory scenario.

As a final note, the Agency emphasizes that some cost and economic impacts would be likely to occur even if the wastes are retained within the Mining Waste Exclusion, because adequately protective standards under an eventual Subtitle D program would probably require the construction of new disposal units at most plants, as reflected by the Subtitle D-Plus scenario presented here.

8.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Iron Blast Furnace and Steel Furnace Slag

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of iron blast furnace and steel furnace slags is relatively low compared to other mineral processing wastes studied in this report. These wastes do not exhibit any of the four characteristics of hazardous waste. Review of the available data on blast furnace and steel furnace slag solid samples and leachate constituent concentrations indicates that only seven constituents are present at concentrations greater than 10 times the conservative screening criteria used in this analysis. In blast furnace slag, concentrations of manganese, iron, lead, arsenic, and silver exceed screening criteria by more than a factor of 10. Concentrations of manganese, iron, chromium, thallium, and arsenic in steel furnace slag exceed one or more of the conservative screening criteria in one or more samples by more than a factor of 10. In addition, aqueous extracts of both blast furnace and steel furnace slag are highly alkaline (pH up to 11.7). These exceedances indicate the potential for the slags to pose risks under very conservative, hypothetical exposure conditions. The actual exposure conditions at the active facilities, however, are not as conducive to human health or environmental damage as those upon which the screening criteria are based, in large part because the slags consist of large solid fragments that are not easily dispersed, and from which contaminants are not readily released. These findings lead EPA to conclude that the intrinsic hazard of these slags is relatively low.

Based on a review of the site-specific conditions at 11 facilities, the potential for blast furnace and steel furnace slag to cause significant impacts appears low at most of the active facilities. The potential for significant releases to ground water is often limited by a low net recharge and a large depth to ground water. The potential for significant surface water impacts is limited by the large particle size of the slag (which precludes erosion) as well as the large distances to water bodies, large surface water flow rates, and great downstream distances to potential receptors at many sites. The large particle size of the slag also limits the potential for significant airborne releases.

This overall low-risk conclusion is supported by the general lack of documented cases of damage attributable to the slags. Even though the slags have been generated and managed at many sites for several decades, EPA identified only one damage case and that case is associated with an inactive facility that was operated under rather unusual conditions. EPA believes that the management controls and environmental conditions at a few of the active facilities are, in theory, also favorable for contaminant releases to ground and surface water, but no releases attributable to the slags are known to have occurred at these sites in the past.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The conditions that currently limit the potential for significant threats to human health and the environment are expected to continue to limit risks in the future in the absence of more stringent federal regulation. The character of the waste is not expected to change and no new blast furnace or primary steel furnace facilities are expected to be constructed in the near future. The slags are widely used at off-site locations, which conceivably could be conducive to releases and risks at present and in the future. However, based on the paucity of documented cases of damage from blast furnace and steel furnace slag, EPA believes that the conclusion of low hazard can be extrapolated to off-site locations of slag disposal or use and to other locations where slag might be used in the future.

Both iron blast furnace slag and steel furnace slag are processed, sold, and used extensively for a variety of purposes, such as road base material, fill, asphaltic concrete aggregate, and railroad ballast. Consequently, both types of slag, particularly iron slag, are often handled as commodities rather than wastes. Ongoing research efforts suggest that new processing technologies will allow the use of slag for additional purposes, which would further reduce the quantity of ferrous metal slag requiring disposal.

State regulation of blast furnace and steel furnace slag is similar in the five states that were reviewed for purposes of this report. For the most part, the states exempt slag from regulation when it is reprocessed or stored temporarily (i.e., not disposed permanently). Iron and steel slag management, therefore, generally is not subject to solid waste (or other land-based) regulation in any of these states, though in some cases waste slag is disposed of in a permitted landfill. Slags that are disposed of permanently on-site or sent off-site to an approved landfill are generally subjected only to minimal requirements (e.g., covers, run-on/run-off controls). As with solid waste regulation, the application of water regulations (i.e., state and/or federal NPDES requirements) to slag wastes generally is not extensive, though it varies considerably from state to state and facility to facility. Moreover, with few exceptions, the states are imposing only minimal, if any, fugitive dust controls on slag waste piles. The management of these slags under solid waste regulations, however, is likely to change dramatically in the near future. Four of the five study states are in the process of proposing or implementing new waste regulations which would address these materials, while the fifth state recently enacted new ground-water protection legislation. Presumably these new regulations will result in more comprehensive and stringent management and disposal practices, though the extent to which this is likely to happen is unclear.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of iron and steel slags, the general absence of documented damages associated with these materials, and the fact that iron and steel slags do not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating iron and steel slags under RCRA Subtitle C.

Iron and Steel Air Pollution Control Dust/Sludge

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of blast furnace and steel furnace APC dust/sludge is generally moderate to high in comparison with the other mineral processing wastes studied in this report. Based on EP leach test results of blast furnace APC dust/sludge, 4 out of 70 samples (from 3 out of 16 facilities tested) contain lead concentrations in excess of the EP toxicity regulatory levels. Selenium was also measured in EP leachate of blast furnace and steel furnace APC dust/sludge in concentrations that exceed the regulatory level in 1 out of 64 samples of blast furnace APC dust/sludge and 1 out of 7 samples of steel furnace APC dust/sludge. Moreover, blast furnace APC dust/sludge contains 12 constituents at concentrations that exceed one or more of the conservative screening criteria used in this analysis by more than a factor of 10. In steel furnace APC dust/sludge, the concentrations of eight constituents exceed one or more of the conservative screening criteria by more than a factor of 10. In addition, aqueous extracts of both blast furnace and steel furnace APC dust/sludge are highly alkaline (pH up to 12.5). While releases and exposures are generally not expected to be as large as the hypothetical conditions upon which the screening criteria are based, the dusts/sludges consist of small particles that are prone to environmental release and transport when not properly controlled.

Based on an examination of the site-specific conditions at 17 facilities, the current management of blast furnace and steel furnace APC dust/sludge poses a low threat at some facilities but a moderate to high threat at others. In general, the potential for the dust/sludge to cause significant ground-water impacts is limited at most sites that manage the waste in a dry form (in stockpiles, landfills, waste piles, etc.) because of the low net recharge, depth to ground water, and/or distance to potential receptors. When managed in impoundments, however, there is a considerably greater potential for the dust/sludge contaminants to migrate into ground water. EPA believes that the potential for the dust/sludge contaminants to migrate into surface water is high at 13 of the facilities because of the wastes' small particle size, a lack of engineered controls to limit releases, and a close proximity to surface water bodies. However, contaminants entering rivers near all but four of these facilities are likely to be readily assimilated by the rivers' large flow. Considering the susceptibility of the dust/sludge to wind erosion, the exposed surface area of waste management units, the lack of dust suppression controls, atmospheric conditions, and population distributions, there is also a relatively high potential for airborne releases and exposures at seven facilities. Despite these theoretical conclusions about potential hazards, EPA did not identify a single case of environmental degradation that can be attributed to the dust/sludge. Therefore, considering the site-specific conditions together with the lack of damage cases, EPA concludes that the dusts/sludges pose an overall moderate risk.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

As discussed above, APC dust/sludge waste management practices and environmental conditions at a number of iron and steel production facilities may allow contaminant releases and moderate risks. Continuation of current management practices in the absence of more stringent federal regulation will continue to pose risks to human health and the environment from APC dusts/sludges into the future. For example, only 1 of the 5 facilities evaluated in this analysis that manages these wastes in impoundments utilizes engineered controls such as liners or leachate collection systems to restrict releases to ground water. Similarly, although the dust is susceptible to wind erosion, only 8 of the 15 facilities that manage dust in landfills or waste piles practice any dust suppression measures. Therefore, environmental releases can occur and, considering the intrinsic hazard of the dust/sludge, significant exposures could occur if affected ground water is used as a source of drinking water.

In addition to the potential impacts at the facilities evaluated in this analysis, threats to human health and the environment may occur at other locations now and in the future as a result of off-site disposal of APC dust/sludge. For example, five facilities reported that they sent all their blast furnace APC dust/sludge off-site for disposal in 1988, and although risks from these off-site locations have not been evaluated in detail because of a lack of site-specific information, it is likely that dust/sludge management at some of these locations may present threats to human health or the environment. The production of steel has increased steadily in recent years, though future growth in demand is expected to be moderate. EPA believes that much of this future demand will be met by mini-mills (which utilize secondary materials and do not generate special wastes) rather than by the addition of new blast furnace or steel furnace facilities.

The management and disposal of APC dust and sludge are, to a large extent, not being addressed under solid waste regulations by the five states reviewed for this report, though these wastes are landfilled by facilities in at least two states and are therefore subject to all pertinent regulations governing landfills. APC dust and/or sludge that is disposed of permanently on-site or sent off-site to an approved landfill generally is subjected only to minimal requirements (e.g., covers, run-on/run-off controls). As with solid waste regulations, the application of water regulations (i.e., state and/or federal NPDES requirements) to APC dusts and sludges generally is not extensive, though it varies considerably from state to state and facility to facility. Moreover, with few exceptions, the states are imposing only minimal, if any, fugitive dust controls on APC dust/sludge waste piles. The management of these wastes under solid waste regulations, however, is likely to change dramatically in the near future. Four of the five states studied for this report are in the process of proposing or implementing new waste regulations that would address these materials, while the fifth state recently enacted new ground-water protection legislation. Presumably these new regulations will result in more comprehensive and stringent management and disposal practices, though the extent to which this is likely to happen is unclear.

Costs and Impacts of Subtitle C Regulation

EPA has evaluated the costs and associated impacts of regulating iron blast furnace APC dust/sludge and steel furnace APC dust/sludge as hazardous wastes under RCRA Subtitle C. EPA's waste characterization data indicate that these materials may exhibit the hazardous waste characteristic of EP toxicity at three and two facilities, respectively. Because neither of these wastes exhibited hazardous characteristics at the majority of facilities that were sampled and because there were only a small total number of EP toxicity test exceedances, EPA assumed that these wastes would not exhibit characteristics (and hence, be subject to regulation in the absence of the Mining Waste Exclusion) at facilities that were not sampled. For iron blast furnace APC dust/sludge, costs of regulatory compliance under the full Subtitle C scenario range from $68,000 per year at the Fairless Hills facility (which recycles its dust) to more than $10 million annually at Bethlehem's Sparrows Point plant; these costs might impose potentially significant economic impacts on the operators of two of the three affected plants. For steel furnace APC dust/sludge, Subtitle C compliance would result in incremental costs of about $2.3 million and $3.3 million at the two affected facilities. Application of the more flexible Subtitle C-Minus regulatory scenario would result in compliance costs that are approximately 55 percent lower. Costs under the Subtitle C-Minus and Subtitle D-Plus scenarios are similar (or identical) at all three affected iron facilities and both affected steel plants, because adequately protective waste management unit design and operating standards are essentially the same under both scenarios, given the nature of the waste and the environmental settings in which it is currently managed.

Costs of full Subtitle C compliance would comprise a potentially significant fraction of the value of shipments of and value added by one affected iron producer (Sparrows Point). Compliance costs at the other four ferrous metals facilities are moderate or low, based upon the Agency's screening criteria. Under the less stringent Subtitle C-Minus scenario, compliance costs are not likely to impose significant impacts on any of the affected facilities. Given the modest nature of the prospective cost impacts of modified Subtitle C and Subtitle D regulation, and the relatively healthy position of domestic ferrous metals producers, EPA does not believe that potential regulatory compliance costs under RCRA Subtitle C would impose significant economic impacts upon affected facilities. These costs would not be shared among all domestic producers (affected facilities account for approximately 13 percent of domestic iron capacity, and seven percent of carbon steel capacity), and therefore, affected facilities may be put at a competitive disadvantage with respect to other domestic producers. Nevertheless, the Agency does not believe that the long-term profitability and continued operation of these plants would be threatened by a decision to regulate either iron or steel APC dust/sludge under Subtitle C.

In addition, it is worthy of note that these impacts would be likely to occur even in the absence of a decision to remove the air pollution control wastes from the Mining Waste Exclusion, because adequately protective waste management standards under a Subtitle D program would require the construction of new waste management units at most plants, implying significant new capital expenditures.

Finally, EPA believes that no significant disincentives for recycling or utilization of the APC dusts and sludges would be created if a change in the regulatory status of these wastes were to occur. Recycling is currently the predominant alternative to disposal that is applied to these materials. It is possible that tighter regulatory controls on the management of APC dust/sludge might serve to promote even greater recycling than has occurred in the recent past (approximately 36 percent of iron APC dust/sludge was recycled in 1988). Utilization of the dusts and sludges has not been widely reported, though limited quantities of iron blast furnace APC dust/sludge were sold for metal recovery (zinc) in 1988. It is not likely that removing iron blast furnace or steel furnace APC dusts/sludges from the Mining Waste Exclusion and thereby subjecting them to regulation as hazardous wastes would significantly limit or prevent this practice.

Chapter 9
Hydrofluoric Acid Production

For purposes of this report, the hydrofluoric acid production industry consists of three facilities that, as of September 1989, were active[1] and reported generating two special mineral processing wastes: fluorogypsum and process wastewater from hydrofluoric acid production.[2] The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

9.1 Industry Overview

Hydrofluoric acid is used primarily for the production of fluorocarbon chemicals, including fluoropolymers and chlorofluorocarbons.[3] Hydrofluoric acid is also used in the aluminum processing industry for the manufacture of synthetic cryolite and aluminum fluoride for reduction cells. In addition, it is used in the manufacture of uranium tetrafluoride, an intermediate in the processing of nuclear fuel and explosives. Furthermore, hydrofluoric acid is used in petroleum alkylation, oil and gas well treatment, stainless steel pickling, and cleaning and etching in some specialty glass and electronics applications. It is also utilized in the manufacture of fluorine chemicals used in herbicides, fluoride salts, plastics, water fluoridation, rare metals processing, and other applications.

The three currently active facilities and their production capacities are shown in Exhibit 9-1. The Geismar facility initiated operations in 1967 and was modernized in 1983; the Calvert City facility (formerly owned by Pennwalt Corp.) began operations in 1949 and was modernized in 1959.[4] A full SWMPF Survey response was not submitted by the LaPorte facility; therefore, no dates of initial operation or modernization are available for that facility. The aggregate 1988 production of hydrofluoric acid for the Geismar and Calvert City facilities was 116,795 metric tons; using the aggregate production capacity for the two facilities as reported in Exhibit 9-1, the average annual capacity utilization rate was 97.3 percent.

More than 70 percent of the reported fluorspar consumption in the U.S. in 1989 was for hydrofluoric acid production.[5] The reported consumption of acid-grade fluorspar has risen throughout the last half of the decade from 383,000 metric tons in 1985 to 449,000 metric tons estimated in 1989. This rise in acid-grade fluorspar consumption indicates that the demand for hydrofluoric acid has risen throughout the late 1980s.[6] The U.S. imported approximately 119,000 metric tons of hydrofluoric acid in 1988, nearly all of it (98 percent) from Canada and Mexico.[7]

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[1] A hydrofluoric acid facility was operated by Essex Chemical Corporation in Paulsboro, NJ until being "mothballed" in 1987. This facility, representing about five percent of the total 1987 aggregate production capacity (1989 Directory of Chemical Producers, SRI International, p. 691) is not addressed in this report.

[2] Several production facilities are operating which produce hydrofluoric acid as an intermediate product in the formulation of commercial chemicals or compounds. The 1989 Directory of Chemical Producers (SRI International, p. 691) reports, for example, that "Aluminum Company of America produces hydrofluoric acid as a nonisolatable product;" Bureau of Mines has confirmed that ALCOA produces hydrofluoric acid at Point Comfort, TX. These facilities did not nominate as special wastes any hydrofluoric acid production waste streams from their operations, are not considered to be part of the primary hydrofluoric acid industry, and therefore, are not addressed in this report.

[3] Bureau of Mines, 1987. Minerals Yearbook, 1987 Ed., p. 373.

[4] Allied Signal, Inc., 1989, and Pennwalt Corp., 1989. Company responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[5] David E. Morse, U.S. Bureau of Mines, "Fluorspar," Minerals Yearbook, 1988 Ed., p. 3.

[6] M. Michael Miller, U.S. Bureau of Mines, "Fluorspar," Mineral Commodity Summaries, 1990 Ed., p. 60.

[7] Morse, op. cit., p. 7.

Exhibit 9-1
Domestic Hydrofluoric Acid Producers

Owner	Location	Capacity (MT)[a]
Allied Signal	Geismar, LA	95,000
E.I. duPont	LaPorte, TX	68,000
Attochemical, N.A.	Calvert City, KY	25,000

(a) SRI International, 1987. Directory of Chemical Producers–United States, 1987 Ed., p. 964.

Generally, U.S. producers of hydrofluoric acid are very competitive in the world market. U.S. firms are able to import low-cost Mexican acid-grade fluorspar for domestic hydrofluoric acid production. Since all of the acid-grade fluorspar used in the production of hydrofluoric acid is currently imported, the establishment of additional hydrofluoric acid production facilities is limited more by market access requirements than a lack of raw materials. The demand for hydrofluoric acid may increase in the future due to the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The U.S. and 22 other countries are party to the protocol, which calls for significant reductions in chlorofluorocarbon (CFC) consumption over the next decade. This could affect the demand for hydrofluoric acid because its primary use is in the production of fluorocarbon chemicals, including CFCs, and substitutes for CFCs are likely to require increased amounts of flourine. Alternatively, CFC substitutes could themselves require use of hydrofluoric acid, so that a CFC phase-out could actually increase demand for hydrofluoric acid.

Hydrofluoric acid is produced from acid-grade fluorspar (CaF_2), which is reacted with sulfuric acid in a heated retort kiln to produce hydrogen fluoride gas, as shown in Exhibit 9-2.[8] The residue remaining after retorting is calcium sulfate anhydrite, commonly known as fluorogypsum, which is a special waste. This solid is slurried in process water as it exits the kiln and is transported either to the waste management units[9] or, at the duPont plant, to a production operation for further processing for sale as a byproduct.[10] The crude product gas is purified by scrubbing; process wastewater reportedly is generated by this process as well.[11] The process wastewater, the second special waste generated by this sector, is stored/treated in on-site surface impoundments and then reused in the process operations or discharged. The hydrogen fluoride gas is condensed and distilled to form anhydrous hydrogen fluoride, a colorless fuming liquid. This liquid may be sold as is or absorbed in water to form hydrofluoric acid.

9.2 Waste Characteristics, Generation, and Current Management Practices[12]

The three hydrofluoric acid facilities generate both solid and aqueous special mineral processing wastes, which are fluorogypsum and process wastewater, respectively.

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[8] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 283.

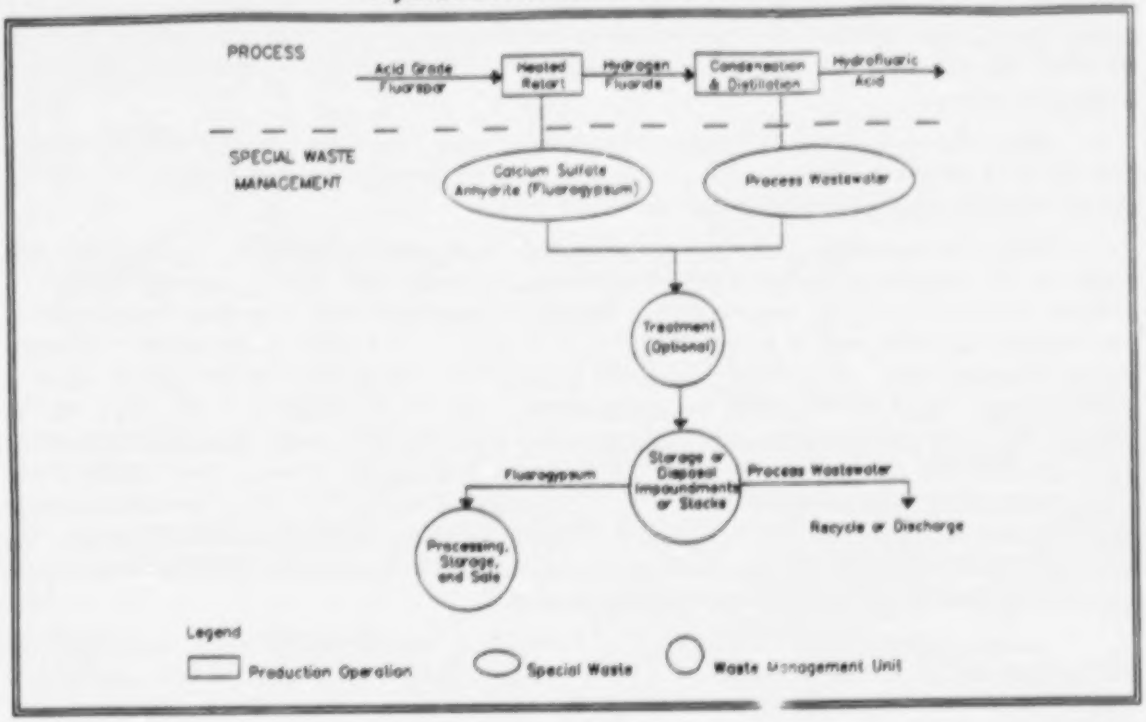
[9] Allied Signal, Inc., 1989. Public comments from Allied Signal, Inc. addressing the 1989 Proposed Reinterpretation of the Mining Waste Exclusion (Docket No. MW2P00020); November 8, 1989, p. 1.

[10] At the duPont facility, lime is added when the fluorogypsum is quenched in order to enhance the chemical characteristics of the material for construction applications.

[11] Pennwalt, 1989. Public comments from Pennwalt Corporation addressing the 1989 Proposed Reinterpretation of the Mining Waste Exclusion (Docket No. MW2P00013); November 8, 1989, p. 1.

[12] All responses, unless otherwise noted, are from the response of Allied Signal, Inc. and Pennwalt Corp. to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities," conducted in 1989.

Exhibit 9-2
Hydrofluoric Acid Production


PROCESS
Acid Grade Fluorspar
Heated Retort
Hydrogen Fluoride
Condensation & Distillation
Hydrofluoric Acid
SPECIAL WASTE MANAGEMENT
Calcium Sulfate Anhydrite (Fluorogypsum)
Process Wastewater
Treatment (Optional)
Storage or Disposal Impoundments or Stacks
Fluorogypsum
Process Wastewater
Recycle or Discharge
Processing, Storage, and Sale
Legend
Production Operation
Special Waste
Waste Management Unit

Fluorogypsum

Fluorogypsum is a solid material consisting primarily of fine particles of calcium sulfate, usually less than 0.02 mm in diameter, that is slurried for transport from the kilns to waste management units.

Using available data on the composition of fluorogypsum, EPA evaluated whether the waste exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on analyses of 4 samples from 2 facilities (Geismar and Calvert City) and professional judgment, the Agency does not believe the fluorogypsum exhibits any of these characteristics. All eight of the inorganic constituents with EP toxicity regulatory levels were measured in concentrations (using the EP leach test) that were at least two orders of magnitude below the regulatory levels.

EPA estimates that the total quantity of fluorogypsum generated in 1988 at the three active facilities was 894,000 metric tons, ranging from 241,000 to 329,000 metric tons. The average annual generation was 297,000 metric tons with an average waste to product ratio of 4.83.

Because the two materials are largely co-managed at all three facilities, the management of fluorogypsum is discussed in the next section, along with process wastewater.

Process Wastewater

Process wastewater is an aqueous liquid, the chemical constituents of which include fluoride, calcium, and sulfate, with smaller amounts of iron and silicon, as well as many trace metals.

Using available data on the composition of hydrofluoric acid process wastewater, EPA evaluated whether the wastewater exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, the Agency does not believe that the wastewater is reactive, ignitable, or EP toxic. All eight of the inorganic constituents with EP toxicity regulatory levels were measured in concentrations (using the EP leach test) that were no more than 0.6 times the regulatory levels. Some wastewater samples, however, exhibit the characteristic of corrosivity. Analyses of the pH of hydrofluoric acid process wastewater at the Geismar and Calvert City facilities indicated that the wastewater was corrosive in all of the nine samples analyzed, sometimes with pH values as extreme as 1.00 (for comparison, pH levels below 2.0 are operationally defined as corrosive wastes).

EPA estimates a total of 13.6 million metric tons of process water are generated annually, ranging from 2.9 to 5.7 million metric tons. The average generation per facility is 4.5 million metric tons and the average ratio of process wastewater to hydrofluoric acid product is 73.63.

Each of the three facilities manages the two special wastes somewhat differently. At the Calvert City facility, the fluorogypsum is slurried in process wastewater and routed with other process wastewaters to a treatment facility where the pH of the combined streams is adjusted with lime. The entire treated slurry is then routed to an on-site surface impoundment, which received over 3.8 million cubic meters (one billion gallons) of water in 1988. The fluorogypsum settles to the bottom and accumulates there until the pond is filled to capacity. After the solids settle, the liquids are routed to a 16 hectare (40 acre) clarifying pond, the pH is adjusted again, and the water is either recycled or discharged to a nearby river. Once filled, the settling ponds are closed with the fluorogypsum in place and a new pond is opened. There are three settling ponds at this facility, two of which are closed. Each of the closed ponds is between 20 and 30 hectares in area, ranges from 4.5 to 9 meters deep, and holds an estimated 3,200,000 metric tons of dried, solid fluorogypsum. The active pond covers approximately 16 hectares, is 9 meters deep, and held (as of mid-1989) approximately 1.3 million metric tons of fluorogypsum submerged beneath liquid.

At the Geismar facility, fluorogypsum is slurried with recycled process water and pumped to fluorogypsum stacks; the facility's stacks are devoted entirely to storage and disposal of fluorogypsum in a manner "facilitating reclamation" (through aging of fluorogypsum in the stacks). The fluorogypsum solids settle to the bottom of holding ponds on top of the stack, and are dredged and dumped immediately adjacent to the ponds to initially form and subsequently build up berms or dikes. The fluorogypsum is dredged and dumped in this fashion on a continuous basis as the holding ponds are filled, slowly increasing the height of the surrounding berms.

Given this management practice, the fluorogypsum exists in three different physical forms at the Geismar facility: (1) as sediment submerged beneath liquid in a holding pond; (2) as wet sediment/sludge freshly dredged and placed on the berms; and (3) as dried solids on the berms. When wet, fluorogypsum has a texture similar to wet cement (a very moist, pasty mixture of solid particles ranging from sand size to cobbles) and, when dry, the fluorogypsum is a very hard, solid mass, not unlike dried cement, rock, or wallboard.

The combined area of the fluorogypsum stack covers almost 17 hectares (43 acres), and the berms range from 11 meters to 20 meters high. As of late 1988, the total quantity of fluorogypsum accumulated in the stack was roughly 2.7 million metric tons. Transport water and precipitation run-off that drains from the stacks are held in an impoundment for reuse in the operation; additional process wastewater may be routed directly to this impoundment, may be used in on-site operations, or may be directly recycled to the hydrofluoric acid operation.

As solids settle out in these ponds, overflow effluent is gravity fed from one pond to the next until the clarified process wastewater eventually reaches a final surface impoundment termed a "clearwell pond." This impoundment covers almost 4.1 hectares (10 acres), is roughly 2.5 meters deep, and holds roughly 5.7 million cubic meters (1.5 billion gallons) of wastewater and 45,400 metric tons of sludge. From the clearwell pond, the process wastewater is recycled on-site for a variety of uses.

Fluorogypsum at the LaPorte facility is lime-neutralized at the point of generation and is transported in slurry form (in process wastewater) to a gypsum stack, after which it undergoes further processing and subsequent sale for a number of construction-related uses.

9.3 Potential and Documented Danger to Human Health and the Environment

In this section, EPA discusses two of the study factors required by Section 8002(p) of RCRA for the special wastes generated in the hydrofluoric acid sector: (1) potential risk to human health and the environment associated with the management of fluorogypsum and hydrofluoric acid process wastewater; and (2) documented cases in which danger to human health and/or the environment has been proven. Overall conclusions about the hazards associated with each of these two wastes are based on the Agency's evaluation of these two factors.

9.3.1 Risks Associated With Fluorogypsum and Hydrofluoric Acid Process Wastewater

Any potential danger to human health and the environment posed by fluorogypsum and hydrofluoric acid process wastewater depends on the presence of hazardous constituents in the wastes and the potential for exposure to these constituents.

Fluorogypsum Constituents of Potential Concern

EPA identified chemical constituents in fluorogypsum that may present a hazard by collecting data on the composition of this waste and evaluating the intrinsic hazard of the chemical constituents.

Data on Fluorogypsum

EPA's characterization of fluorogypsum and its leachate is based on data from two sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); and (2) industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, 4 ions (nitrate, fluoride, chloride, and sulfate), 1 radionuclide (radium-226), and 2 organic compounds (benzene and methyl ethyl ketone) in fluorogypsum solids and leachate. The leachate data were generated using EP, SPLP, and TCLP leach tests. Two of the three facilities that generate fluorogypsum are represented by these data: Allied-Signal in Geismar, LA, and Attochem in Calvert City, KY.

There are no particularly noteworthy trends in the data. With a very few exceptions, the concentrations of individual constituents in fluorogypsum solids are consistent (within an order of magnitude) across the two data sources and two facilities; the EP, SPLP, and TCLP leach test results are also usually within an order of magnitude of each other across the two facilities. However, several constituents were detected in higher concentrations in SPLP leach tests than EP leach tests. Neither facility is reported to have consistently higher (or lower) contaminant concentrations than the other.

Process for Identifying Constituents of Concern

As discussed in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if fluorogypsum contains any chemical constituents that could pose an intrinsic hazard. The Agency performed this evaluation by first comparing the concentration of chemical constituents to screening criteria and then by evaluating the environmental persistence and mobility of constituents that are present at levels above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which constituents in fluorogypsum are released to the environment and migrate to possible exposure points. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic organisms, and water resources (see Exhibit 2-3). Given the conservative (i.e., protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Based on a comparison of the concentrations of 24 constituents to the screening criteria summarized above, there do not appear to be any constituents in fluorogypsum solids in concentrations that exceed the screening criteria. That is, even under a very conservative set of release and exposure conditions, the chemical concentrations in fluorogypsum solids are not expected to pose a significant risk.

Of the 25 constituents analyzed in fluorogypsum leachate, eight are present in concentrations that exceed the screening criteria: arsenic, sulfate, lead, chromium, mercury, iron, manganese, and aluminum (see Exhibit 9-3). All of these constituents are metals or other inorganics that do not degrade in the environment. Arsenic and sulfate exceeded the screening criteria most frequently (in 100 percent of the samples); however, only lead exceeded the screening criteria by more than a factor of six. Despite these exceedances of the screening criteria, none of the samples contained any constituents in excess of the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Arsenic, lead, and chromium concentrations in the fluorogypsum leachate may pose a health risk if the leachate is released to ground water, diluted by a factor of 10 or less during migration to a downgradient drinking water well, and ingested without prior treatment over a long period of time. The diluted concentration of arsenic could result in a cancer risk exceeding 1×10^{-5}.
- If the fluorogypsum leachate is released to ground water and diluted by less than ten-fold, the resulting concentrations of arsenic, sulfate, lead, chromium, iron, and manganese could exceed the drinking water maximum contaminant level (MCL) for these constituents.
- Concentrations of lead, chromium, mercury, and aluminum in the fluorogypsum leachate may present a threat to aquatic organisms if the leachate migrates (with less than 100-fold dilution) to surface waters.

Although the two sources of data used to characterize the composition of fluorogypsum do not provide data on the radionuclide content of fluorogypsum leachate, such data are available from field monitoring results at the Allied-Signal site and at a site in Louisiana where fluorogypsum was used to construct a test highway embankment (see the damage case descriptions for more detail). Seven samples of run-off/seepage/leachate from this site contained elevated gross alpha radiation levels, ranging from 79 pCi/l to 226 pCi/l. Two additional samples of "ambient" surface water collected adjacent to the test embankment also contained elevated gross alpha concentrations of 24 to 103 pCi/l. The levels in all eight samples exceed the primary drinking water MCL of 15 pCi/l (by factors that range from 2 to 15). Similarly, two run-off samples contained radium-226 concentrations of 8 and 22 pCi/l, both of which exceed the MCL of 5 pCi/l.[13]

These exceedances of the screening criteria, by themselves, do not demonstrate that fluorogypsum poses a significant risk, but rather indicate that the waste may present a hazard under a set of very conservative hypothetical release, transport, and exposure conditions. To determine the potential for fluorogypsum to cause significant impacts, EPA analyzed the actual conditions that exist at the facilities that generate and manage the waste (see the following section on release, transport, and exposure potential).

Process Wastewater Constituents of Potential Concern

Using the same process outlined above for fluorogypsum, EPA identified chemical constituents in hydrofluoric acid process wastewater that conceivably may present a hazard.

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[13] EPA has only one sample result for the radionuclide concentration in fluorogypsum solids. In one fluorogypsum sample from the Allied-Signal facility, radium-226 was measured in a concentration of 2.5 pCi/g, which is below the screening criterion of 5 pCi/g.

Exhibit 9-3
Potential Constituents of Concern in Fluorogypsum Leachate(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Arsenic(c)	7 / 7	Human Health* Resource Damage	7 / 7 2 / 7	2 / 2 1 / 2
Sulfate(c)	5 / 5	Resource Damage	5 / 5	1 / 1
Lead(c)	3 / 7	Human Health Resource Damage Aquatic Ecological	2 / 7 3 / 7 2 / 7	1 / 2 1 / 2 1 / 2
Chromium(c)	6 / 7	Human Health Resource Damage Aquatic Ecological	2 / 7 2 / 7 2 / 7	1 / 2 1 / 2 1 / 2
Mercury(c)	1 / 7	Aquatic Ecological	1 / 7	1 / 2
Iron	2 / 2	Resource Damage	1 / 2	1 / 2
Manganese	2 / 2	Resource Damage	1 / 2	1 / 2
Aluminum(c)	2 / 2	Aquatic Ecological	1 / 2	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. 'Human health' screening criteria noted with an '*' are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer health effects.

(c) Data for this constituent are from SPLP leach test results.

Data on Process Wastewater

Two data sources were used to characterize the composition of hydrofluoric acid process wastewater: data gathered by OSW in a 1989 field sampling effort, and data submitted by industry in response to a §3007 request in 1989. These sources provide data on the concentrations of 20 metals, sulfate, and pH in process wastewater and wastewater leachate from the Geismar and Calvert City facilities.

Based on a comparison of the sample concentrations, the data from the two facilities are generally consistent, though the concentrations of barium, chromium, and lead in the wastewater from the Allied-Signal plant are one order of magnitude higher than corresponding concentrations at the Calvert City facility.

Identified Constituents of Potential Concern

Of the 22 constituents analyzed in hydrofluoric acid process wastewater, 14 are present in concentrations that exceed the screening criteria. These 14 constituents, the type of screening criteria they exceed, and the frequency with which they exceed the criteria are summarized in Exhibit 9-4. All of these constituents are inorganics that do not degrade in the environment.

Of the 14 constituents that exceed the screening criteria, only six were present in concentrations that exceed the criteria by more than a factor of 10: antimony, copper, iron, lead, manganese, and thallium. Measured concentrations of iron in the wastewater exceed the screening criteria by the widest margin (by as much as a factor of 160). None of these constituents were ever detected at levels that exceed the EP toxicity regulatory levels, however, and based on professional judgment, EPA does not believe that the wastewater exhibits the hazardous waste characteristics of ignitability and reactivity. However, some wastewater samples exhibit the characteristic of corrosivity. The pH values of the wastewater may be either very low (e.g., 1.0 to 1.9 at the Geismar and Calvert City plants prior to treatment) or very high (e.g., 12 to 14 at the LaPorte plant after treatment).

These exceedances of the risk screening criteria indicate the potential for the following types of impacts:

- If hydrofluoric acid process wastewater is released to ground water and diluted by a factor of 10 or less during migration to a downgradient drinking water well, concentrations of lead, chromium, antimony, and thallium could pose a health risk if the water is ingested without treatment on a long-term basis.
- Concentrations of iron, copper, aluminum, nickel, zinc, lead, and chromium in the process wastewater could present a threat to aquatic organisms if the wastewater migrates (with 100-fold dilution or less) to surface waters.
- If the process wastewater is released to ground water and diluted by a factor of 10 or less, the resulting concentrations of several constituents could render the water unsuitable for certain uses (i.e., cause water resource damages). Specifically, the resulting concentrations of iron, manganese, sulfate, lead, and chromium could exceed the drinking water maximum contaminant levels for these constituents. The concentrations of molybdenum, aluminum, nickel, and vanadium could also exceed irrigation guidelines, rendering the water less desirable for agricultural purposes.
- If the process wastewater is released to ground or surface water at the Geismar or Calvert City facilities, the resulting pH levels may be less than the lower pH limit established for use as drinking water (6.5). Conversely, if the process wastewater is released at the LaPorte facility, the pH in receiving waters may be higher than the pH limit for drinking water use (8.5). Both low and high pH may cause increased corrosivity and an unpleasant taste.

As discussed above, these exceedances of the screening criteria, by themselves, do not demonstrate that the process wastewater poses a significant risk, but rather indicate that the wastewater may present a hazard under a very conservative hypothetical set of release, transport, and exposure conditions. To determine the potential for the wastewater to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the waste.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of fluorogypsum and hydrofluoric acid process wastewater as they were generated and managed at the three hydrofluoric acid production plants in 1988. It does not assess the hazards of off-site use or disposal of the wastes. Neither of the wastes are disposed of off-site, but fluorogypsum may be used off-site as a lightweight aggregate, as discussed in Section 9.5. The hazards associated with the off-site use of fluorogypsum are discussed in the context of a damage case in Section 9.3.2. The following analysis also does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of sufficient data to predict future conditions.

Exhibit 9-4
Potential Constituents of Concern in Hydrofluoric Acid Process Wastewater (Total)[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Iron	1 / 1	Resource Damage Aquatic Ecological	1 / 1 1 / 1	1 / 1 1 / 1
Manganese	1 / 1	Resource Damage	1 / 1	1 / 1
Thallium	1 / 1	Human Health	1 / 1	1 / 1
Copper	1 / 1	Aquatic Ecological	1 / 1	1 / 1
Antimony	1 / 1	Human Health	1 / 1	1 / 1
Molybdenum	1 / 1	Resource Damage	1 / 1	1 / 1
Aluminum	1 / 1	Resource Damage Aquatic Ecological	1 / 1 1 / 1	1 / 1 1 / 1
Nickel	1 / 1	Resource Damage Aquatic Ecological	1 / 1 1 / 1	1 / 1 1 / 1
Zinc	1 / 1	Aquatic Ecological	1 / 1	1 / 1
Sulfate	1 / 1	Resource Damage	1 / 1	1 / 1
Vanadium	1 / 1	Resource Damage	1 / 1	1 / 1
Lead	1 / 2	Human Health Resource Damage Aquatic Ecological	1 / 2 1 / 2 1 / 2	1 / 2 1 / 2 1 / 2
Chromium	1 / 2	Human Health Resource Damage Aquatic Ecological	1 / 2 1 / 2 1 / 2	1 / 2 1 / 2 1 / 2
pH	9 / 9	Resource Damage	9 / 9	2 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

Ground-Water Release, Transport, and Exposure Potential

As discussed in the preceding section, EPA and industry test data show that several constituents in fluorogypsum leachate and hydrofluoric acid process wastewater are present in concentrations above the screening criteria. Considering the pH of the leachate and wastewater, several of the constituents are expected to be mobile in ground water if they migrate from the waste management units, including arsenic, lead, chromium, manganese, iron, thallium, copper, antimony, nickel, zinc, and sulfate.

The potential for these constituents to be released to ground water and cause subsequent impacts varies according to site-specific conditions, as summarized below:

- The fluorogypsum stack and clearwell pond at the Geismar, LA facility are underlain by in-situ clay and recompacted local clay. Both the stack and the pond are surrounded by an unlined "interceptor ditch" that is designed to capture run-off and leachate; fluids collected in this ditch are pumped back to the clearwell pond. Although the water table is as shallow as 3 meters beneath the site, the uppermost useable aquifer is considerably deeper, roughly 55 meters below the land surface.[14] This deeper aquifer is used primarily for livestock watering. The nearest downgradient well appears to be located 2.4 km (1.5 miles) away. The facility reports that it does not routinely monitor ground-water quality at the site.

- The settling ponds at the facility in Calvert City, KY are underlain by in-situ clay. The ponds are surrounded by slurry walls and ground-water monitoring wells to help control leachate migration. An aquifer that is used as a rural domestic drinking water supply is located roughly 5 meters below the land surface. Because the ponds at this site are roughly 9 meters deep, it is likely that the base of the ponds extends beneath the water table. The nearest downgradient drinking water well appears to be located 3.6 km (2.3 miles) from the facility.

- The fluorogypsum stack and process wastewater impoundments at the facility in LaPorte, TX are surrounded by an unlined drainage ditch to help capture seepage and run-off. Although ground water is relatively shallow (6 meters deep) and therefore potentially susceptible to contamination, the site is located in an extremely industrialized area near the Houston shipping channel and the suitability of the surficial ground water for domestic use appears limited. The closest potential users of the ground water are located more than 200 meters downgradient. The extent to which the shallow ground water has been contaminated (if at all) is not known because no monitoring has been conducted in recent years.

Although the fluorogypsum and process wastewater management units at each site are equipped with some type of leachate control system, these controls do not appear to be completely sufficient to prevent contamination of the shallow ground water at each site. This is substantiated by ground-water monitoring around the ponds at the Calvert City facility, which has indicated levels of cadmium, fluoride, iron, manganese, pH, and total dissolved solids that exceed the drinking water standards. Fluorogypsum and process wastewater are possible contributors to this contamination. As discussed in the preceding sections, EPA sample analyses found iron and manganese to be readily leachable from fluorogypsum, and found high concentrations of iron and manganese and low pH levels in process wastewater. Contamination seeps around the clearwell pond at the Geismar facility (see the damage cases) provide further indication of the potential for existing on-site management practices to cause ground-water contamination.

Given its extremely high or low pH, migration of the process wastewater into ground water may significantly damage the value of the ground water as a potential resource. A low pH may cause the need for heavier chlorination, whereas a high pH may cause increased halogen reactions. Both excessively high and low pH values will cause increased corrosivity. Although high and low pH values may cause an unpleasant taste, a wide range of pH values for drinking water can be tolerated from a human health standpoint.[15]

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[14] Company responses to the "National Survey of Solid Wastes from Mineral Processing Facilities" (EPA 1989) from the Arcadian phosphoric acid plant, which is adjacent to the Allied Signal plant, indicate that useable ground water occurs at a depth of 24 meters at this location.

The toxic constituents present in any ground-water contamination are not expected to cause significant human health impacts at present because:

- The shallow ground water beneath the Geismar facility is not useable, the useable aquifer is considerably deeper and more protected, the deeper aquifer does not appear to be used for human consumption, there are no downgradient wells that are close, and the concentrations of most constituents of concern in the waste exceed conservative screening criteria by less than a factor of 10 (and thus are likely to be well below levels of concern at distant exposure points);
- Existing slurry walls should help contain any contamination at the Calvert City plant and, even if contamination did escape, the closest well is far away and not likely to be significantly affected by the generally low concentrations of toxic constituents; and
- The shallow ground water at the LaPorte facility is not likely to be used for drinking within close distances.

EPA acknowledges, however, that human health risks could occur in the future if ground water near the waste management units is ever used for drinking, or if the wastewater is managed in a more sensitive environmental setting in the future.

Surface Water Release, Transport, and Exposure Potential

The fluorogypsum stack and clearwell pond area at the plant in Geismar, LA is located roughly 600 meters from the Mississippi River and 1,200 meters from the Bayou Breaux (a relatively small stream). Significant migration of contaminants into the Mississippi River appears unlikely because a levee on the bank of the river should prevent overland erosion and because ground water [illegible] this area appears to migrate from the river toward the facility. Even if contaminants did migrate into the Mississippi, the river's very large flow provides a significant enough assimilative capacity to disperse the contaminants. However, as discussed in the damage case section, the smaller Bayou Breaux could be contaminated in the event of a pipeline spill or a large failure of the fluorogypsum stack berms. Routine releases to the bayou are expected to be largely precluded by the interceptor ditch that surrounds the waste management units at this facility. The level of fluids collected in this ditch is controlled by an automatic pump that turns on when the fluid level reaches a certain height and pumps the liquid back to the clearwell pond.

The nearest surface water body at the plant in Calvert City, KY is the Tennessee River, located roughly 1,040 meters away. It appears unlikely that any contamination originating from the ponds could migrate to this river, either via ground-water seepage or direct overland run-off, because the ponds are equipped with slurry walls and run-on/run-off controls. The plant discharges treated process wastewater to the river in accordance with a NPDES permit and monitors the concentration of contaminants in the effluent on a weekly basis. The plant also monitors the ambient water quality, and reports that it has not observed an exceedance of drinking water or ecological protection criteria in the river. In the vicinity of the plant, the Tennessee River is very large, with an annual average flow of 16 million cubic meters (4,211 million gallons) per day. This river is used as a source of industrial process water at a point 520 meters downstream and as a source of drinking water at a point 25 km (16 miles) downstream. Considering all of these factors, it is unlikely that the routine management of fluorogypsum and process wastewater at this plant could cause significant surface water impacts.

The LaPorte facility is located roughly 50 meters from the San Jacinta Bay. Releases to this water body are possible, either through ground-water seepage or by direct overland runoff. Although the fluorogypsum and process wastewater impoundment at the site are surrounded by a drainage ditch that is designed to control overland run-off, plant personnel have indicated that the ditch has overflowed several times because of severe storms. Because the San Jacinta Bay is saline, it is not used for drinking water. Therefore, any contamination originating from the LaPorte facility is not likely to pose a direct drinking water threat, but could conceivably cause an aquatic ecological threat.

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[15] EPA. 1984. National Secondary Drinking Water Regulations, EPA 570/9-76-000, June 1984, p. 30.

Air Release, Transport, and Exposure Potential

Because the primary constituents of fluorogypsum and process wastewater from hydrofluoric acid production are nonvolatile inorganics, contaminants can only be released to air in the form of dust particles. The release of dust, however, is precluded by the form of the wastes; fluorogypsum is either a hard solid mass or is submerged beneath liquid, while the process wastewater is a liquid. The most likely airborne release mechanism appears to be the potential for dust suspension caused by vehicular traffic on top of the fluorogypsum stacks in Louisiana and Texas. Any such airborne releases should have a minimal impact because, based on sampling data from EPA and industry, the fluorogypsum solids do not contain any constituents in concentrations that may pose a risk through the inhalation pathway.

Proximity to Sensitive Environments

All three hydrofluoric acid plants are located in or near environments that are either vulnerable to releases of contaminants or have high resource value that may warrant special consideration. In particular:

- The Calvert City plant is located in an endangered species habitat, according to the operator's response to the SWMPF Survey.
- The Geismar and Calvert City plants are both located in 100-year floodplains; large floods could create the potential for large, episodic releases.
- All three of the facilities are located within one mile upgradient of a wetland (defined here to include swamps, marshes, bogs, and other similar areas). Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural water, provide flood and storm damage protection, and afford a number of other benefits.
- The Calvert City plant is located in a fault zone. This creates the potential for earthquake damages to the slurry walls that help to contain ground-water contamination from the ponds at this site.

Risk Modeling

Based upon the evaluation of available data, the intrinsic hazard of the wastes and factors that influence risk presented above, a review of the risk modeling results for other mineral processing wastes, and a review and evaluation of information on documented damage cases (presented in the next section), EPA concluded that process wastewater and fluorogypsum were not high priorities for quantitative risk modeling. Accordingly, no risk modeling was performed.

9.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the performance of process wastewater and fluorogypsum waste management practices at the three active hydrofluoric acid facilities: Attochem (Pennwalt) in Calvert City, Kentucky; duPont in LaPorte, Texas; and Allied Signal in Geismar, Louisiana. The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found documented environmental damages associated with the co-management of process wastewater and fluorogypsum at one facility, Allied-Signal in Geismar, and with the off-site utilization of fluorogypsum from the Geismar facility.

Allied-Signal, Geismar, Louisiana

This facility is located south of Baton Rouge in an industrial/agricultural area; the nearest residence is about 1.6 km (one mile) away. Its receiving waters are the Bayou Breaux and the Mississippi River. Ground water in this area is used for livestock watering.

Releases from the Gypsum Stack/Clearwell

Fluorogypsum generated from the production of hydrofluoric acid is slurried with process water as it is removed from the furnace; the resulting slurry is transferred through a conduit system to an impoundment on the top of a fluorogypsum stack. Seepage and run-off from the fluorogypsum stack is collected in clay-lined ditches and flows into an impoundment referred to as the clearwell. Some water from the clearwell is recycled into various plant operations, while excess water is discharged as needed into the Mississippi River via a NPDES permitted outfall after passing through a wastewater treatment plant.[16,17]

To avoid excessive levels of water in the clearwell during periods of high rainfall, which could lead to catastrophic failure of the containing levee, Allied has on occasion bypassed the treatment facility and discharged the clearwell water directly into the Mississippi River. This situation is allowed by EPA and Louisiana Department of Environmental Quality (LADEQ) under proper emergency circumstances (i.e., prior notice, reasonable cause). Emergency discharges occurred in January 1983;[18] and from August 1983 through October 1983.[19] In April 1984, Allied notified EPA of its intention to again bypass the treatment facility when discharging its clearwell water if its level rose another 30 cm, to a depth of 9 meters (30 feet).[20]

Allied has discharged or spilled untreated wastewater during other situations as well. In April 1978, Allied noted a seepage area northwest of the clearwell; subsequent sampling revealed a low pH and the presence of phosphate in the seepage.[21] In July 1978, a gypsum line break reduced pH levels in a drainage ditch feeding into Bayou Breaux.[22] Allied discovered another leak in October 1980 in the northeast corner of the clearwell. Consultants to Allied noted that contaminated water penetrating the clay surfacing was "resulting in vegetation kills which cannot be tolerated."[23] In August 1981, a gypsum slurry transport line ruptured and a portion of the Bayou Breaux dropped in pH from around 7 to as low as 2.6.[24]

One of the primary difficulties in managing the gypsum stack and clearwell areas is preventing their physical failure. Stack failures have occurred in the past. In May 1979, Allied's east gypsum stack failed,

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[16] Allied-Signal, Inc., 1989. Company response to the "National Survey on Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[17] LA Stream Control Commission, 1977. Permit Application to Discharge Wastewater Revision form by William Chamberlain, General Manager of Allied. July 1, 1977.

[18] EPA Region VI, 1983. Letter from Myron O. Knudson, Director Water Management Division, to Herman J. Baker, Allied Chemical plant manager, Re: Administrative Order Docket No. VI-83-057, NPDES Permit No. LA0006181. January 1, 1983.

[19] Louis J. Capozzoli and Associates, Inc. Consulting Engineers, 1983. Letter from Louis J. Capozzoli and Associates, Inc. to Allied Chemical, Re: Modification of Operations Gypsum Stack and Clearwell. August 8, 1983.

[20] Swidler, Berlin and Strelow, 1984. Letter from L. Miller to Jack Ferguson, EPA Region VI, Re: NPDES Permit No. LA0006181. April 24, 1984.

[21] Allied Chemical, 1980. Letter to Kenneth Cooper, EPA Region VI, Re: (additional information on area northwest of Allied's phosphate clearwell). February 2, 1980.

[22] Allied Chemical, 1978. Letter from W.P. Chamberlain, General Manager to R.A. Lafleur, Executive Secretary, LA Stream Control Commission, Re: (gypsum line break). July 31, 1978.

[23] Allied Chemical, 1980. Letter from W.J. Dessert, Manager Environmental to Dale Givens, LA Water Pollution Control Division, Re: (Letter and supplemental information for October 24, 1980 meeting between Allied Chemical and EPA Region VI). November 11, 1980.

[24] Allied Chemical, 1981. Letter from W.P. Chamberlain, General Manager to Jack Ferguson, Chief Industrial Compliance Section (6E-WC), EPA Region VI, Re: NPDES Permit No. La 0006181. October 20, 1981.

resulting in the overflow of low pH gypsum slurry water into a roadside ditch along Highway 30.[25,26] An estimated 95 percent of the spilled water was recovered. In October 1980, consultants to Allied Chemical identified four interrelated clearwell and gypsum stack problems: (1) levee overtopping; (2) levee stability (high risk of stack failure); (3) levee crest subsidence; and (4) levee toe leak.[27] In August 1983, another slide (failure) occurred on Allied's gypsum stack.

Releases Associated with the Use of Gypsum as Road Construction Material

Within the time period from 1986 to 1987, in an effort to find a profitable use for the large quantities of gypsum waste accumulating at Allied Signal's facility, Louisiana Synthetic Aggregates, Inc. (LASYNAG) began marketing the gypsum as a road base material.[28] According to consulting engineers contracted by LASYNAG, the gypsum was processed by milling (excavating and screening) the material from the fluorogypsum stockpile located at the Allied-Signal hydrofluoric acid plant in Geismar, Louisiana. Once milled, the fluorogypsum was marketed and shipped as "Florolite."[29]

In 1987, LASYNAG had the milled fluorogypsum analyzed by several laboratories for different parameters. One laboratory reported that with a resistivity of 500 ohms-cm and a pH of 5.2, the material is considered very corrosive for most iron and steel products. The laboratory also stated that the high sulfate content and the low pH would likely make the material corrosive to concrete as well.[30]

During 1987, after several rounds of requests and data submittals, Louisiana's Department of Transportation and LADEQ's Office of Solid and Hazardous Waste authorized the use of Florolite on various road shoulders, embankments, and base courses.[31,32] At least some of these approved projects were completed, including road work at a mobile home park.[33]

In July 1988, the City of New Orleans Department of Streets concluded that the material would be acidic and corrosive for iron, steel, and concrete products, and deemed the use of Florolite as a road base material in the City inadvisable.[34]

On June 7, 1989, LASYNAG began construction of a test embankment for the "U.S. Highway 90 relocation construction project" through a stretch of wetlands in southern Louisiana near Amelia. After three

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[25] Allied Chemical, 1979. Letter from W.P. Chamberlain to R.A. Lafleur, with attachments, Re: None. (failure of east gypsum stack). June 25, 1979.

[26] EPA Region VI, 1983. Letter from Myron O. Knudson, Director Water Management Division, to Herman J. Baker, Allied Chemical plant manager, Re: Administrative Order Docket No. VI-83-057, NPDES Permit No. LA0006181. January 21, 1983.

[27] Allied Chemical, 1980. Letter from W.J. Dessert, Manager Environmental to Dale Givens, LA Water Pollution Control Division, Re: (Letter and supplemental information for October 24, 1980 meeting between Allied Chemical and EPA Region VI). November 11, 1980.

[28] LASYNAG, located in Gretna, Louisiana, is owned by Coastal Contractors, Inc., of Baton Rouge.

[29] G&E Engineering, Inc., 1989. Analyses of Florolite Aggregate Runoff and Surface Waters - U.S. Highway 90 Reallocation Construction Site--Obtained in Response to LADEQ Compliance Order. September, 1989.

[30] Analysis Laboratories, Inc., 1987. Letter to C. Lundstrom, Eustis Engineering Co., Re: Examination of Florolite Sample. March 27, 1987.

[31] Louisiana Department of Transportation. Projects Containing Florolite. Date unknown.

[32] LADEQ, 1987. Letter from J. Koury, OSHW, to D.G. Azar, LASYNAG, Re: Use of Allied Chemical Company Gypsum. June 8, 1987.

[33] LADEQ, 1987. Complaint form received by Jesse Chang from anonymous resident in Twin Lakes Mobile Home Park, Re: None. (use of Allied Chemical's gypsum for road paving and fill). January 15, 1987.

[34] City of New Orleans Department of Streets, 1988. Letter from R.J. Kaufmann to J. Poolych, LASYNAG, Re: None (Use of Florolite as road base material). July 15, 1988.

weeks, LADEQ responded to complaints of dying biota and found "extremely acidic pH and high conductivity in water adjacent to the roadbed." Construction was ceased immediately.[35]

Exhibit 9-5 summarizes the analytical results for run-off/seepage/leachate samples collected near a Florolite stockpile at the Amelia test site. These results show pH values ranging from 1.6 to 2.9, while sulfate concentrations ranged from 6,030 to 11,500 mg/L, up to 46 times the National Secondary Drinking Water MCL of 250 mg/L. Arsenic, cadmium, chromium, lead, and mercury levels also exceeded Primary MCLs in run-off/seepage/leachate samples. In addition, gross alpha and radium levels were detected at levels above MCLs in several samples.[36]

As shown in Exhibit 9-6, ambient surface water samples collected adjacent to the embankment exhibited elevated levels of pH, sulfates, salinity, and specific conductivity, as well as arsenic, cadmium, chromium, and lead. The elevated concentrations in comparison to the more remote ambient surface water sampling locations were attributed by LASYNAG to leaching and/or run-off from the "Florolite" embankment.[37]

In addition to sampling the Florolite stockpile at the Amelia site, Allied also sampled "fluorogypsum run-off/leachate water" from the Allied-Signal fluorogypsum stockpile. From analysis of one sample, elevated levels of arsenic, cadmium, chromium, lead, mercury, gross alpha radiation, and radium, were detected (Exhibit 9-7).[38]

LASYNAG is now undertaking remedial measures to remove the environmental hazard posed by Florolite at the Amelia test site.[39]

9.3.3 Findings Concerning the Hazards of Fluorogypsum and Process Wastewater

Although both fluorogypsum and hydrofluoric acid process wastewater contain several constituents in concentrations that could pose significant risk under worst-case exposure conditions, the process wastewater is intrinsically much more hazardous. Based on an analysis of nine samples, the wastewater consistently exhibits the hazardous waste characteristic of corrosivity (the pH may be as low as 1.0 at the Geismar and Calvert City facilities, and as high as 14 at the LaPorte facility). The wastewater also contains six constituents in concentrations that exceed the screening criteria by a factor of 10 or more, though none of the constituents were detected in excess of the EP toxicity regulatory levels. In contrast, no constituents were detected in the fluorogypsum solids in concentrations that could pose a risk, and only one contaminant in the fluorogypsum leachate (lead) exceeded the screening criteria by more than a factor of 10. Run-off/leachate samples collected at the Allied-Signal stack as well as the test embankment site near Amelia, LA indicate that fluorogypsum leachate may contain elevated levels of gross alpha radioactivity and radium-226, but the gross alpha and radium concentrations that were measured rarely exceeded the MCL by more than a factor of 10. Furthermore, based on available data and professional judgment, EPA does not believe that fluorogypsum exhibits any of the characteristics of a hazardous waste.

Based on an analysis of existing exposure and environmental conditions at the three active hydrofluoric acid production plants, there is a relatively high potential for shallow ground-water contamination caused by the seepage of process wastewater and the migration of fluorogypsum leachate. This is substantiated by documented ground-water contamination near the impoundment at the Calvert City facility and observed

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[35] G&E Engineering, Inc., 1989. Analyses of Florolite Aggregate Runoff and Surface Waters - U.S. Highway 90 Reallocation Construction Site - Obtained in Response to LADEQ Compliance Order. September, 1989.

[36] Ibid.

[37] Ibid.

[38] Ibid.

[39] Ibid.

Exhibit 9-5
Run-off/Seepage/Leachate from Florolite at Test Site Near Amelia, LA

Parameter	MCL (mg/L)[b]	No. Samples Exceeding MCL[a]	Range of Exceedance (mg/L)[b]
As	0.05	4	0.2 – 1.1
Cd	0.01	7	0.07 – 0.56
Cr	0.05	7	0.67 – 9.5
Pb	0.05	7	0.3 – 1.6
Hg	0.002	2	0.0043 – 0.0060
Gross Alpha	15 pCi/L	6	79 – 226 pCi/L
Total Radium	5 pCi/L	2	8 – 22 pCi/L
pH	6.5 – 8.5 S.U.	7	1.4 – 2.9 S.U.

(a) Out of 7 samples collected.
(b) Except as noted.

Exhibit 9-6
"Ambient" Surface Water (Area Affected by Florolite) at Test Site Near Amelia, LA

Parameter	MCL (mg/L)[b]	No. Samples Exceeding MCL[a]	Range of Exceedance (mg/L)[b]
As	0.05	1	0.15
Cd	0.01	2	0.03 – 0.07
Cr	0.05	2	0.39 – 1.3
Pb	0.05	2	0.2 – 0.2
Gross Alpha	15 pCi/L	2	24 – 103 pCi/L
pH	6.5 – 8.5 S.U.	10	2.1 – 6.4

(a) Out of 10 samples collected.
(b) Except as noted.

Exhibit 9-7
Fluorogypsum Run-off/Leachate Water From The Allied-Signal Fluorogypsum Stockpile

Parameter	MCL (mg/L)	Sample Concentration (mg/L)[a]
As	0.05	0.06
Cd	0.01	0.18
Cr	0.05	3.6
Pb	0.05	0.5
Hg	0.002	0.0062
Gross Alpha	15 pCi/L	140 pCi/L
pH	6.5 - 8.5 S.U.	1.7 S.U.

(a) One sample collected (07/11/89).

contamination seeps around the process wastewater "clearwell" pond at the Geismar facility. This contamination is not expected to cause significant health risks at present, either because the shallow ground water is not likely to be used at close downgradient distances (as is the case at Geismar and LaPorte) or because the waste management units are equipped with slurry walls and a monitoring well network to help contain any contamination (as is the case at Calvert City). However, the very low or high pH of the process wastewater could cause considerable ground-water resource damage (e.g., affected ground water may be corrosive, have an objectionable taste, and require additional treatment prior to use).

The potential for significant releases to surface water during routine operations is limited at each site by some type of management control, including perimeter ditches, retention ponds, and/or slurry walls. Even if contaminants did migrate to nearby surface waters at the Calvert City and La Porte facilities, both of the sites borders major water bodies (the Tennessee River and San Jacinta Bay) that should be able to readily assimilate the low pollutant loadings that would be expected. The smaller Bayou Breaux near the Geismar facility may receive contaminants in the event of spills and gypsum stack failures, but routine releases to the bayou are expected to be minimal given the site's perimeter ditch system and the large distance (1,200 meters) separating the bayou from the waste management units. Occasional overflows and emergency discharges to surface waters have occurred during major storms, but these are generally isolated events that are controlled under the NPDES program.

Considering the form of the wastes (nonvolatile liquids and moist/wet solids) and the absence of any contaminants that could pose an inhalation threat, the potential for significant releases and exposures via the air pathway appears very low.

Documented cases of damage identified by EPA provide two important findings. First, the damage case at the Geismar facility demonstrates difficulties in preventing the physical failure of gypsum stacks. There have been at least six separate incidents since 1979 in which the stack at this facility failed (i.e., slumped, collapsed, and/or overflowed). Although relatively rare, these failures allow sporadic large releases of the highly acidic process wastewater. Second, the documented case of environmental contamination caused by the off-site use of fluorogypsum demonstrates that the distribution and use of this material warrants close control. Specifically, when used off-site for applications that result in contact with the land (e.g., road construction), pH adjustment is required to prevent adverse environmental impacts, and run-off controls are needed to prevent the spread of potentially harmful concentrations of contaminants.

9.4 Existing Federal and State Waste Management Controls

9.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations," which provide the basis for the minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT effluent limitations for existing sources applicable to discharges resulting from the production of hydrofluoric acid include (40 CFR 415.82):

Pollutant	Daily Maximum	Monthly Average
Total Suspended Solids	11 Kg/kkg	5.3 Kg/kkg
Total Fluorine	6.1 Kg/kkg	2.9 Kg/kkg
Total Nickel	0.036 Kg/kkg	0.011 Kg/kkg
Total Zinc	0.12 Kg/kkg	0.036 Kg/kkg
pH	6-9	6-9

BAT effluent limitations for existing sources for discharges resulting from the production of hydrofluoric acid include (40 CFR 415.83):

Pollutant	Daily Maximum	Monthly Average
Total Fluorine	3.4 Kg/kkg	1.6 Kg/kkg
Total Nickel	0.020 Kg/kkg	0.0060 Kg/kkg
Total Zinc	0.072 Kg/kkg	0.022 Kg/kkg

Effluent limitations for new sources of these discharges include (40 CFR 415.85):

Pollutant	Daily Maximum	Monthly Average
Total Suspended Solids	6.0 Kg/kkg	3.0 Kg/kkg
Total Fluorine	3.4 Kg/kkg	1.6 Kg/kkg
Total Nickel	0.020 Kg/kkg	0.0060 Kg/kkg
Total Zinc	0.072 Kg/kkg	0.022 Kg/kkg
pH	6-9	6-9

In Texas and Louisiana, states which do not have EPA-approved NPDES programs, EPA Regional personnel have stated that they would apply the above guidelines. The State, however, may also adopt state water quality standards for control of discharges from hydrofluoric acid manufacturing facilities.

9.4.2 State Regulation

The three hydrofluoric acid production facilities addressed by this report, all of which generate and co-manage fluorogypsum and process wastewater, are located in Kentucky, Louisiana, and Texas. All three of these states were selected for regulatory review (see Chapter 2 for a discussion of the methodology used to select study states for detailed regulatory review).

All three states with hydrofluoric acid production facilities exclude mineral processing wastes from hazardous waste regulation. Of the three states, Louisiana appears to be the most comprehensive in its coverage of both fluorogypsum and process wastewater, which the state classifies as industrial solid wastes. Although no requirements have been drafted specifically for fluorogypsum waste piles, facility owner/operators must comply with general waste pile provisions for soils (e.g., stability, permeability), hydrologic characteristics, precipitation run-on and run-off, location standards, security, safety, and waste characterization. Similarly, process wastewater management must meet general industrial waste surface impoundment requirements such as run-on controls, liner requirements, design standards (e.g., to prevent overtopping and minimize erosion), waste characterization, and ground-water monitoring requirements. Surface impoundments must be dewatered and clean-closed (i.e., all residuals removed) or closed according to solid waste landfill closure provisions. Louisiana also requires that owners/operators of all industrial solid waste piles and surface impoundments maintain financial responsibility for the closure and post-closure care of those waste units. Although Louisiana does not have an approved NPDES program, the state does require state permits for the discharge of leachate or run-off to surface waters. Finally, Louisiana air regulations require that its one hydrofluoric acid processing facility manage its wastes in a manner necessary to minimize fugitive dust emissions.

As does Louisiana, Texas classifies mineral processing wastes, including wastes from the production of hydrofluoric acid, as industrial solid wastes. Because the hydrofluoric acid facility in Texas disposes of its wastes on property that is both within 50 miles of the facility and controlled by the facility owner/operator, the state has not required the facility to obtain a solid waste disposal permit. The facility has notified the state of its waste disposal activities, as required, and has obtained federal NPDES and Texas wastewater discharge permits. Finally, Texas air regulations include provisions that could apply to the disposal of hydrofluoric acid processing wastes, though it does not appear that these provisions have been applied to the facility.

Kentucky also classifies the hydrofluoric acid processing wastes generated at its one facility as solid waste and requires the facility to maintain a solid waste permit that includes provisions for ground-water monitoring and waste characterization. The facility's surface impoundment is not designed to discharge to either ground or surface water. Kentucky's facility also maintains a NPDES permit, though state officials believe that all of the process wastewater is recycled at the facility, and must meet stormwater run-off standards for both its operating and closed fluorogypsum ponds. The state recently proposed a new residuals regulation that may apply to hydrofluoric acid processing wastes. If these wastes are subject to the new rule, the facility owner/operator could be required to upgrade existing ground-water monitoring efforts, continue waste characterization, undertake the formal closure of waste management units, and demonstrate financial responsibility. Finally, although general fugitive dust emission control requirements apply, the nature of fluorogypsum as it is currently managed at the facility effectively precludes fugitive dust problems and state officials were unaware of any such problems.

In summary, all three states with hydrofluoric acid processing facilities exclude the fluorogypsum and process wastewaters generated at those facilities from hazardous waste regulation. Moreover, all three states address these wastes under their solid waste regulations to varying degrees. Of the three states, Louisiana currently appears to be the most comprehensive in its regulation under solid waste provisions. Kentucky applies some regulatory controls to its facility and appears to be preparing to strengthen those requirements under a recently promulgated residuals regulation. Texas classifies hydrofluoric acid processing wastes as solid wastes, but exempts its facility from the requirement to obtain a solid waste disposal permit because the wastes are disposed of on-site. All three facilities maintain federal and/or state NPDES permits. Finally, although all three states have general fugitive dust emission control provisions, none of the states appear to have applied those requirements to hydrofluoric acid processing wastes because of the nature of fluorogypsum and process wastewater.

9.5 Waste Management Alternatives and Potential Utilization

This section provides a brief summary of current management practices and potential areas of utilization for both fluorogypsum and process wastewater, because they are generally co-managed.

Fluorogypsum

In 1988, the three U.S. facilities generated an estimated 890,000 metric tons of fluorogypsum.[40] The primary alternative to disposal of fluorogypsum in stacks is utilization in construction materials as a lightweight aggregate. Two of the three facilities sell fluorogypsum from their stacks to on-site contractors who subsequently sell it to construction firms and highway departments. The third facility disposes of all of its fluorogypsum. This facility (Attochem's facility in Calvert City, Kentucky) currently disposes of all its fluorogypsum in a surface impoundment, though the firm is currently investigating the possibility of utilizing the fluorogypsum to produce a road base aggregate.[41]

Allied Signal's Geismar, Louisiana plant sent over 323,000 metric tons of fluorogypsum to its disposal stack in 1988 and removed and sold 140,000 metric tons.[42] Louisiana Synthetic Aggregate, an on-site contractor, retrieves the fluorogypsum from the stack, screens and sizes it, adds a quantity of reagent to the product for neutralization, and sells the fluorogypsum to construction companies and local highway departments for use as a lightweight aggregate in road beds.[43] There has been one reported damage case associated with use of fluorogypsum without neutralization from Allied's facility as an embankment material (see Section 9.3.2 for details). Louisiana Synthetic Aggregate is investigating the use of fluorogypsum in building materials (i.e., plaster of Paris, self-leveling sub-floor base) as a substitute for natural gypsum.[44]

Of the three U.S. facilities generating fluorogypsum, the duPont plant in LaPorte, Texas has had the greatest success in selling its fluorogypsum for utilization in construction. duPont sells its fluorogypsum to an on-site contractor, Gulf States Materials, which markets the product in the Houston area. The sales to production ratio for duPont's fluorogypsum in 1988 and 1989 were 153 percent and 161 percent, respectively. Approximately 60 percent of the material sold is used as a limestone replacement for road base aggregate and 40 percent is used as a fill material. Except for screening and sizing, the fluorogypsum sent to the stack at the LaPorte facility does not require any processing before being utilized. If the material is used as road base, cement or fly ash may be added to give it pozzollanic characteristics. DuPont expects that the market for fluorogypsum as a construction material will continue to grow as it has in the 11 years since the material was first sold.[45]

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[40] Company responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[41] Pennwalt Corporation, company response to the "National Survey of Solid Wastes form Mineral Processing Facilities," U.S. EPA, 1989.

[42] Allied-Signal, Inc., company response to the "National Survey of Solid Wastes form Mineral Processing Facilities," U.S. EPA, 1989.

[43] Personal communication, Dennis Cheuvront, Environmental Supervisor, Allied-Signal Inc., Geismar, Louisiana, May 11, 1990.

[44] Ibid.

[45] Personal communication, Larry Schwarz, Staff Engineer-HF Operation, E.I. DuPont, LaPorte, Texas, May 10, 1990.

Hydrofluoric Acid Process Wastewater

At present, the only waste management practices being applied by the three hydrofluoric acid producers to the process wastewater are returning it to the production process and/or adjusting the pH prior to recycling or discharge. None of the three facilities report that they completely neutralize their process wastewater, and in some cases the recycled wastewater is used because of its acidity.[46] Therefore, the only potential waste management alternative is complete neutralization, though this might reduce the quantity of wastewater that can be recycled.

9.6 Costs and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste management units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C, if land disposal restrictions had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed under different regulatory scenarios by facilities producing hydrofluoric acid. Next, the section discusses the cost implications of requiring these changes to the existing waste management practices. The last part of the section discusses and predicts the ultimate impacts of the increased waste management costs faced by this industry.

9.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented above, EPA believes that process wastewater from hydrofluoric acid production may pose a relatively high risk potential and generally exhibits that hazardous waste characteristic of corrosivity. Accordingly, the Agency has estimated the costs associated with RCRA Subtitle C regulation, as well as with two somewhat less stringent regulatory scenarios, referred to here as

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[46] Company responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

"Subtitle C-Minus" and "Subtitle D-Plus" (a more detailed description of the cost impact analysis and the development of these regulatory scenarios is presented in Chapter 2, above). In the following paragraphs, EPA discusses the assumed management practices that would occur under each regulatory alternative.

The Agency's sampling efforts indicated that the process wastewater at Allied-Signal's Geismar facility exhibits the hazardous characteristic of corrosivity. While the conservative approach would be to assume that the remaining two facilities also generate corrosive process wastewaters, EPA believes that present practices are such that no compliance costs would be imposed on those facilities. The Calvert City facility currently treats its slurried fluorogypsum and process wastewater such that the wastewater leaving the treatment unit is neutral (i.e., with pH of 8, as reported in the SWMPF Survey). The duPont facility reportedly treats its slurried waste stream with lime to bring it to a very high pH, possibly even greater than 12.5, such that the process water may be considered corrosive at the alkaline extreme. The purpose of this treatment is to prepare the gypsum for sale as a byproduct. The Agency assumes that the facility would decrease the extent of its lime treatment to the point at which the process wastewater would not exhibit the corrosivity characteristic (pH < 12.5), and that this treatment process modification would not impose any compliance costs per se.

Because the available data indicate that fluorogypsum does not exhibit any of the characteristics of hazardous waste and has been found to pose only low potential risk, the issues of how waste management costs might change because of new regulatory requirements and what impacts such costs might impose upon affected facilities are moot. Consequently, EPA has not estimated regulatory compliance costs for this waste.

A decision by EPA that Subtitle C regulation is appropriate for process wastewater would result in incremental waste management costs at one facility. The Agency has estimated the incidence, magnitude, and impacts of the costs for that facility; this analysis is presented in the following paragraphs.

Subtitle C

Under Subtitle C standards, hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because hydrofluoric acid production process wastewater is a dilute, aqueous liquid, that is corrosive but non-EP toxic, the management practice of choice under Subtitle C is treatment (neutralization) in a tank. EPA has determined that within the relevant size range, tank treatment is the least-cost management method, and has conducted its analysis accordingly. The scenario examined here involves construction of a Subtitle C surge pond (double-lined surface impoundment), and a tank treatment system. Following neutralization, the treated process wastewater may be reused by the facility (e.g., to slurry fluorogypsum to the gypsum stack or impoundment), just as it is under current practice. The treatment sludge, which is assumed to not be hazardous, is disposed in an unlined disposal impoundment/landfill.

Subtitle C-Minus

Assumed practices under Subtitle C-Minus are identical to those described above for the full Subtitle C scenario, with the exception that some of the strict requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements. Because other Subtitle C provisions apply in full, there are no significant operational differences between the two scenarios.

Subtitle D-Plus

Assumed practices under Subtitle D-Plus are identical to those described above for the full Subtitle C scenario, with the exception that, as under Subtitle C-Minus, some of the strict requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements. Because other Subtitle C provisions apply in full, there are no significant operational differences between this and the other two scenarios.

9.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the hydrofluoric acid sector are presented by regulatory scenario in Exhibit 9-8. Under the Subtitle C scenario, annualized incremental regulatory compliance costs for Allied-Signal's facility are estimated to be $1.8 million greater than baseline (over 8 times the baseline costs). Annualized incremental capital compliance expenditures are estimated at $512,000, approximately 29 percent of total incremental compliance costs.

Under the somewhat less rigorous requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are lower, due to decreased capital construction outlays. Allied-Signal's annualized compliance costs under this scenario are estimated to be $1.7 million greater than baseline (about 8 times baseline costs). The total compliance cost is only about four percent less than that under the full Subtitle C scenario. The primary reason for the difference in waste management costs is the configuration of the surge pond liner system; under the Subtitle C-Minus scenario, disposal units are equipped with a single synthetic/clay liner and leachate collection system, rather than the dual system required under full Subtitle C regulation.

Costs under the Subtitle D-Plus regulatory scenario are virtually identical to those under Subtitle C-minus scenario. The configuration of the surge pond, the only varying factor, is the same for D-Plus as under C-Minus (installation of a composite liner and clean closure). Variations in permitting costs between C-Minus and D-Plus account for the difference in the annual compliance cost.

9.6.3 Financial and Economic Impact Assessment

In order to evaluate the ability of the affected facility to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of the facility and thereby generated financial impact ratios in order to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary hydrofluoric acid producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the hydrofluoric acid industry. The methods and assumptions used to conduct this analysis are described in Chapter 2.

Financial Ratio Analysis

EPA believes that regulation under any of the three scenarios would not significantly affect the financial viability of the one affected facility, Allied-Signal's facility in Geismar, Louisiana. As shown in Exhibit 9-9, the annualized incremental costs associated with waste management under Subtitle C, C-Minus, or D-Plus should only marginally affect the facility in terms of both value added and value of shipments, as indicated by ratio values of less than 1.5 percent in all cases. The only potentially significant impact is indicated by the annualized compliance capital as a percentage of the total annual sustaining capital investment; additional capital approaching ten percent of current levels of sustaining capital would be required to cover increased waste management costs.

Evaluation of Cost/Economic Impacts

EPA believes that stringent regulation of hydrofluoric acid process wastewater as a hazardous waste would not impose highly significant economic or financial impacts on Allied-Signal's facility in Geismar, Louisiana, though a large capital investment relative to current sustaining capital would be required. Furthermore, EPA's analysis suggests that the operator could pass through a portion of any regulatory compliance costs to product consumers, because demand for and prices of hydrofluoric acid have been strong in recent years, and are expected to remain so for the foreseeable future. As a final note, the Agency expects

Exhibit 9-8
Compliance Cost Analysis Results for Management of Hydrofluoric Acid Process Wastewater[(a)]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Allied-Signal - Geismar, LA	236	1,758	3,429	512	1,686	3,046	454	1,583	3,046	454
Total:	236	1,758	3,429	512	1,686	3,046	454	1,583	3,046	454

(a) Values reported in this table are those computed by EPA's cost estimating model and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Costs have been estimated only for facilities for which sampling data indicate that the waste would fail a RCRA hazardous waste characteristic.

Exhibit 9-9
Significance of Regulatory Compliance Costs for Management of Hydrofluoric Acid[(a)]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Allied-Signal - Geismar, LA	1.2%	1.5%	9.7%
Subtitle C-Minus			
Allied-Signal - Geismar, LA	1.1%	1.5%	8.7%
Subtitle D-Plus			
Allied-Signal - Geismar, LA	1.1%	1.4%	8.7%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant digits.
Costs and impacts have been estimated for only the facility for which sampling data indicate that the waste fails a RCRA hazardous waste characteristic.

there to be no significant difference in the cost impacts of the Subtitle C, C-Minus, and D-Plus regulatory scenarios, suggesting that adequately protective management standards will eventually be required, irrespective of whether process wastewater from hydrofluoric acid is retained within the Mining Waste Exclusion.

9.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Fluorogypsum

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of fluorogypsum is relatively low compared to the other mineral processing wastes studied in this report. Fluorogypsum does not exhibit any of the four characteristics of hazardous waste. No constituents in the fluorogypsum solids were detected at levels above the risk screening criteria used in this analysis, and only two constituents -- gross alpha radiation and lead -- were detected in the waste leachate in a concentration that exceeds the screening criteria by as much as a factor of 10. Gross alpha levels as high as 226 pCi/l (15 times the MCL) and radium-226 levels as high as 22 pCi/l (4 times the MCL) were measured in leachate/run-off collected at field locations where fluorogypsum had been disposed. Information collected through EPA's damage case research also indicates that fluorogypsum may be mildly corrosive to iron, steel, and concrete, although not so corrosive as to qualify as a hazardous waste. This residual corrosivity is likely the result of the fluorogypsum being co-managed with the highly acidic process wastewater, rather than an intrinsic property of the fluorogypsum itself.

Based on an analysis of existing release and environmental conditions at the three active hydrofluoric acid plants, there is a relatively high potential for fluorogypsum leachate to migrate into shallow ground water. This is substantiated by documented leachate migration near the impoundment at the Calvert City facility. Such migration, however, is not expected to cause significant impacts, either because the shallow ground water is not likely to be used at close downgradient distances and contaminant concentrations at potential exposure points should be below levels of concern (as is the case at Geismar and LaPorte), or because the waste management units are equipped with slurry walls and a monitoring well network to detect and help contain any ground-water contamination (as is the case at Calvert City). The potential for significant releases to surface water during routine operations is limited at each site by some type of management control, including perimeter ditches, automatic pumps, retention ponds, and/or slurry walls. Even if contaminants did migrate to nearby surface waters, each of the existing sites borders major water bodies (the Mississippi River, the Tennessee River, and San Jacinta Bay) that should be able to assimilate the low pollutant loadings that would be expected during routine operating conditions. Contaminants from the Geismar facility may migrate into a smaller water body, the Bayou Breaux, in the event of a large spill or gypsum stack failure, but routine releases to this bayou are not expected. Occasional overflows and emergency discharges to surface water have occurred during major storms, but these are generally releases of process wastewater rather than fluorogypsum. Such emergency discharges also are isolated events that are controlled under the NPDES program. Finally, considering the form of fluorogypsum (moist/wet solids that dry to form a surface crust) and the fact that no contaminants were detected in the waste at levels that could pose an inhalation threat, the potential for significant releases and exposures via the air pathway also appears low.

Through its damage case research, EPA identified two cases of documented environmental contamination that are associated with the management of fluorogypsum. In one case, fluorogypsum was used to construct a test highway embankment in a wetland near Amelia, LA, resulting in high contaminant concentrations in run-off and ambient surface water at the site. This damage case demonstrates that the distribution and use of this material warrants close control. The other damage case involves at least six separate incidents since 1979 in which the fluorogypsum stack at the Geismar facility has physically failed (i.e., slumped, collapsed, and/or overflowed). In each incident, localized environmental contamination has occurred, but this contamination appears to be more attributable to the process wastewater that was spilled along with the stack failure than to the fluorogypsum.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

As discussed above, the current fluorogypsum management practices and environmental conditions at the three active hydrofluoric acid production facilities may allow leachate from this waste to migrate into shallow ground water, both now and in the future. This potential for migration exists partly because the existing fluorogypsum management units are not lined and are underlain by shallow ground water, and partly because fluorogypsum is co-managed with highly acidic (or basic) process wastewater that can mobilize metals in the gypsum and provide a hydraulic head to drive contaminants into the subsurface. After closure, and if the process wastewater is removed, the potential for leachate migration from this waste will be reduced considerably. This migration is not expected to pose a significant human health and environmental threat at present for the reasons outlined above, and considering the measured contaminant concentrations in fluorogypsum leachate, would pose a hazard in the future only if shallow ground water very near the waste management units is allowed to be used for drinking or agricultural purposes.

There is a relatively high potential for fluorogypsum to be generated and managed at alternate sites in the future. Acid-grade fluorospar that is used as a feedstock is largely imported, such that additional plants could be located nearly anywhere that provides adequate access to water transportation. Although the addition of new plants is uncertain, it is a distinct possibility given that many potential chlorofluorocarbon (CFC) substitutes are likely to require more fluorine than do CFCs.[47] In addition, two of the three active facilities currently sell fluorogypsum to construction firms and highway departments for use at off-site locations. As demonstrated by the damage case in Amelia, LA, such off-site uses can lead to damages if not properly controlled. However, given the low intrinsic hazard of fluorogypsum, damages from off-site uses are likely only in extreme mismanagement scenarios, such as disposal of the material in a wetland (as was the case at Amelia) or disposal in a manner that would allow people to drink largely undiluted leachate.

At present, of the three states with hydrofluoric acid processing facilities, Louisiana appears to be the most comprehensive in its regulation of fluorogypsum under its solid waste provisions. Fluorogypsum is classified as an industrial solid waste in Louisiana, and although the gypsum is not subject to specific requirements, stacks must meet the State's general requirements for solid waste landfills. Owners/operators in Louisiana also must maintain Federal NPDES permits and State air emission permits, the latter of which include provisions for fugitive dust control. The other states where active facilities are located -- Kentucky and Texas -- impose less stringent solid waste and air regulatory requirements on hydrofluoric acid production facilities within their jurisdictions, though Kentucky recently proposed new solid waste regulations that may address the waste more stringently.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of fluorogypsum, the general absence of documented damages associated with the appropriate use of this material, and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating fluorogypsum from hydrofluoric acid production under RCRA Subtitle C.

Hydrofluoric Acid Process Wastewater

Potential and Documented Danger to Human Health and the Environment

In contrast to fluorogypsum, the intrinsic hazard of hydrofluoric acid process wastewater is relatively high compared to the other mineral processing wastes studied in this report. All nine samples of process wastewater that were analyzed (from two of the three active facilities) exhibited the hazardous waste characteristic of corrosivity -- the pH may be as low as 1 at the Geismar and Calvert City facilities, and as high as 14 at the LaPorte facility. In addition, the wastewater contains six constituents in concentrations that exceed the risk screening criteria used in this analysis by a factor of 10, though none of the constituents were detected in excess of the EP toxicity regulatory levels.

Because the process wastewater is co-managed with fluorogypsum, the potential for wastewater to migrate into the environment at the active facilities is similar to that described above for fluorogypsum. However, the extreme pH and higher concentrations of toxic constituents in process wastewater make it a greater potential threat than fluorogypsum. There is a relatively high potential for process wastewater to migrate into shallow ground water at the three facilities, as demonstrated by the contaminant migration observed near the impoundment at the Calvert City facility and the contamination seeps observed around the process wastewater clearwell pond at the Geismar facility. This migration is not expected to pose significant current health risks, either because the shallow ground water is not likely to be used at close downgradient distances (as is the case at Geismar and LaPorte), or because the waste management units are equipped with slurry walls and a monitoring well network to detect and help contain ground-water contamination (as is the case at Calvert City). However, the very low or high pH of the process wastewater could cause considerable ground-water resource damage (e.g., affected ground water may be corrosive, have an objectionable taste, and require additional treatment prior to use). Routine operations are not expected to cause significant surface water impacts, considering the management controls, distances to surface water, and assimilative capacity of nearby waters. Nevertheless, as demonstrated by the damage case at the Geismar facility, there may be occasional spills and emergency discharges of process wastewater that may kill vegetation on affected land and cause short-term pH excursions in surface waters (such emergency discharges are controlled under the NPDES program). Airborne releases and risks associated with the management of process wastewater are not expected to occur, given the physical state of this waste stream.

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[47] Production of CFCs is being phased out due to their adverse effects on stratospheric ozone. Substitute compounds that are less persistent in the atmosphere are expected to have more fluorine atoms per molecule, thus increasing demand for a source of fluorine in the production of these compounds.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

Current process wastewater management practices may allow seepage into ground water, both now and in the future, because the existing waste management units are not lined and are underlain by shallow ground water. The co-management of process wastewater with fluorogypsum enhances the potential for contaminant migration because the highly acidic process wastewater percolating through the fluorogypsum may mobilize metals in the gypsum and provide a force to carry contaminants into the subsurface. In addition, there are difficulties in preventing the physical failure of gypsum stacks. Although rare, these stack failures allow large spills of the process wastewater and intense localized impacts. These releases are expected to continue in the absence of more stringent regulation, and although EPA does not believe that they have caused significant long-term risks at the active facilities, significant exposures could occur if the wastewater is managed in a more sensitive environmental setting in the future. In addition, the corrosive nature of the wastewater would likely render affected ground water near the waste management units unfit for future uses without prior treatment.

While process wastewater is not likely to be used off-site, there is a potential for new hydrofluoric acid production plants to start up at alternate sites in the future. As discussed above for fluorogypsum, more plants may be needed to produce the more fluorine-rich substitutes for CFCs. If constructed, these new plants may be located in environmental settings where the corrosive wastewater may pose substantial risks if not properly controlled.

Finally, of the three States where the active facilities are located, Louisiana appears to be most comprehensive in its regulation of hydrofluoric acid process wastewater. The process wastewater is classified as an industrial solid waste in Louisiana, and although the wastewater is not subject to specific requirements, the wastewater impoundments must meet general requirements for all surface water impoundments. Owners/operators in Louisiana also must maintain Federal NPDES permits for the discharge of process wastewater. In contrast, Kentucky and Texas (the other States where active facilities are located) impose less stringent requirements on hydrofluoric acid production facilities, though Kentucky recently proposed new solid waste regulations that may address process wastewater more directly.

Costs and Impacts of Subtitle C Regulation

Because of the relatively high risk potential of this waste and the fact that EPA waste sampling data indicate that process wastewater from hydrofluoric acid production exhibits the hazardous waste characteristic of corrosivity, the Agency has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. However, information collected by EPA indicates that at two of the three active facilities (LaPorte and Calvert City), neutralization of the process wastewater (i.e., removal of the characteristic of hazardous waste) is part of the current management practice. Consequently, EPA believes that removal of process wastewater from the Mining Waste Exclusion would not impose significant operational or cost impacts on these two facilities. Therefore, EPA's analysis of costs and impacts is limited in scope to the Geismar facility.

Total costs of regulatory compliance at the Geismar hydrofluoric acid plant exceed $1.5 million annually under each of the three regulatory scenarios. Costs under the full Subtitle C, Subtitle C-Minus, and Subtitle D-Plus scenarios are similar (within nine percent of one another), because adequately protective waste management unit design and operating standards are essentially the same under all three scenarios, given the nature of the waste and the environmental setting in which it is currently managed. These compliance costs represent from one to one and one half percent of the value of shipments of and value added by the Geismar facility, though the annualized capital requirements of compliance are on the order of nine to ten percent of the sustaining capital required for the hydrofluoric acid operation. EPA's economic impact analysis suggests that the operator of the potentially affected facility could pass through a portion of any regulatory compliance costs that they might incur to product consumers, because demand for and prices of hydrofluoric acid have been strong in recent years, and are expected to remain so for the foreseeable future. Because the costs of Subtitle C regulatory compliance would not impose significant immediate impacts on the affected facility (less than one and a half percent of value added), because the facility may have some ability to pass any such costs through to product consumers through higher prices, and perhaps most importantly, because two of the three active facilities in the sector currently treat their process wastewater in the manner contemplated here, EPA does not believe that a decision to regulate process wastewater from hydrofluoric acid production under Subtitle C would threaten the long-term profitability or viability of the Geismar facility, or any other future hydrofluoric acid plant.

Finally, EPA is not aware of any significant recycling or utilization initiatives that would be hampered by a change in the regulatory status of this waste. At the one potentially affected facility, the process water is likely to be managed in much the same way as it is currently, with the exception that it would be treated prior to discharge. EPA does not believe that the additional waste management requirements would materially affect the production processes employed at or general operation of the affected facility.

Chapter 10

Primary Lead Processing

The primary lead processing sector consists of five facilities that, as of September 1989, were active and reported generating a special mineral processing waste: slag from smelting and refining. One facility conducts only smelting, a second only refining, and the other three conduct both operations, as is shown in Exhibit 10-1. The bullion from the East Helena smelter is refined at the Omaha refinery, which also processes secondary materials.[1] The data included in this section are discussed in additional detail in a technical background document in the supporting public docket for this report.

Exhibit 10-1
Primary Lead Processing Facilities

Operator/Owner	Location	Type of Operation
ASARCO	East Helena, MT	Smelter
ASARCO	Glover, MO	Smelter and Refinery
ASARCO	Omaha, NE	Refinery
Doe Run/Fluor Corp.[a]	Boss, MO	Smelter and Refinery
Doe Run/Fluor Corp.[a]	Herculaneum, MO	Smelter and Refinery

[a] Bureau of Mines, 1990. Personal communication with BOM Commodity Specialist, 27 June.

10.1 Industry Overview

The primary domestic use of lead is in lead-acid storage batteries. Lead is also used in containers and as an additive for gasoline, though these uses are rapidly declining.[2] Lead also is used to manufacture lead oxides which are used in the battery, glass, ceramics, rubber, and coatings industries.[3]

Three of the five facilities are located in Missouri, one is in Montana, and the other is in Nebraska. The dates of initial operation for these facilities range from 1879 to 1968. Four of the facilities were extensively modernized between 1967 and 1988; the fifth, the Boss, MO facility, which was new in 1968, reportedly has not undergone extensive modernization and is operating intermittently at less than 10 percent of capacity. The three ASARCO facilities have designated their aggregate annual lead refining production capacity, production, and capacity utilization data from the SWMPF Survey as confidential.[4] The Bureau of Mines reports that the estimated production of refined lead from primary processing was 392,000 metric tons in 1988;[5] in the SWMPF Survey, Doe Run reported its 1988 production from its Boss and Herculaneum smelter/refineries as 10,000 and 225,000 metric tons, respectively.

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[1] In addition to the five primary facilities, approximately 50 secondary processing facilities are operating; the operations conducted at these facilities, however, fall outside EPA's established definition of primary mineral processing and accordingly, do not generate special mineral processing wastes. (See 54 FR 36619-36620, September 1, 1989.)

[2] Bureau of Mines, 1987. Minerals Yearbook, 1987 Ed., p. 544.

[3] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 439.

[4] ASARCO and Doe Run, 1989. Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

The U.S. Bureau of Mines estimates that after a sharp decline between 1985 and 1986, the quantity of refined lead produced in the U.S. has slowly but steadily increased from 370,000 metric tons in 1986 to 395,000 metric tons in 1989. With the increasing production rate, the U.S. became a significant lead concentrate exporter in 1989. Recent expansion in the primary lead industry consists of a large new smelting and refining facility coming on-line in late 1989. In addition, mines in Alaska, Idaho, Missouri, and Montana were newly opened, re-opened, or expanded during the late 1980s.[6]

The Bureau estimates that primary smelter production will remain at about 400,000 metric tons in 1990. Domestic consumption of lead is expected to decline slightly in 1990, but, on a worldwide scale, this decrease in consumption is expected to be offset somewhat by increased demand in Asia and, to a lesser extent, in Europe.[7] U.S. output of refined lead is expected to increase slightly in 1990, although this increase should be due entirely to secondary lead output.[8] Future growth in the lead market depends highly upon the level of growth and new developments in the transportation, electrical, and electronics industries.[9]

The sector wide capacity of primary refined lead (i.e., the capacity of the ASARCO/East Helena smelter is not included because all product is sent to a separate refinery) is estimated to be 577,000 metric tons per year. Long-term capacity utilization (i.e., from 1990 to 1995), as reported by the Bureau of Mines, is expected to range from 100 percent at the Glover and Herculaneum facilities to 80, 50, and 20 percent at the East Helena, Omaha, and Boss facilities, respectively.

Primary lead processing consists of both smelting (blast furnace and dross furnace operations) and refining operations, as shown in Exhibit 10-2. In the smelting process, sintered ore concentrate is introduced into a blast furnace along with coke, limestone, and other fluxing materials; the lead is reduced, and the resulting molten material separates into four layers: lead bullion (98 wt. percent lead); "speiss" and "matte," two distinct layers of material which contain recoverable concentrations of copper, zinc, and minor metals; and blast furnace slag.[10] The speiss and matte are sold to copper smelters for recovery of copper and precious metals; the blast furnace slag is stored in piles and partially recycled (at the three Missouri facilities) or disposed (at the Montana facility). The lead bullion is then drossed (i.e., agitated in a drossing kettle and cooled to just above its freezing point) to remove lead and other metal oxides, which solidify and float on the molten lead bullion. The solidified material (referred to as dross), which is composed of roughly 90 percent lead oxide, along with copper, antimony, and other elements, is skimmed off the bullion and fed to a dross furnace for recovery of the non-lead mineral values. About 50-60 percent of the recovery furnace output is slag and residual lead that are both returned to the blast furnace. The remainder of the dross furnace output is sold to copper smelters for recovery of the copper and other precious metals. The lead bullion may also be decopperized before being sent to the refining plant.

Lead refining operations continue the process of removing various saleable metals (e.g., gold and silver, bismuth, zinc, and metal oxides such as antimony, arsenic, tin, and copper oxide). These operations, which are described in detail in the technical background document, are softening, desilverizing, dezincing, and bismuth removal. In the final refining step the lead bullion is mixed with fluxes to remove remaining impurities (e.g., calcium, magnesium, and lead oxide). Reagents (e.g., caustic soda and/or nitrates) may be

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[5] Bureau of Mines, 1990. Personal communication with BOM Commodity Specialist.

[6] William D. Woodbury, 1990. U.S. Bureau of Mines, "Lead," Mineral Commodity Summaries, 1990 Ed., pp. 91, 96, 97.

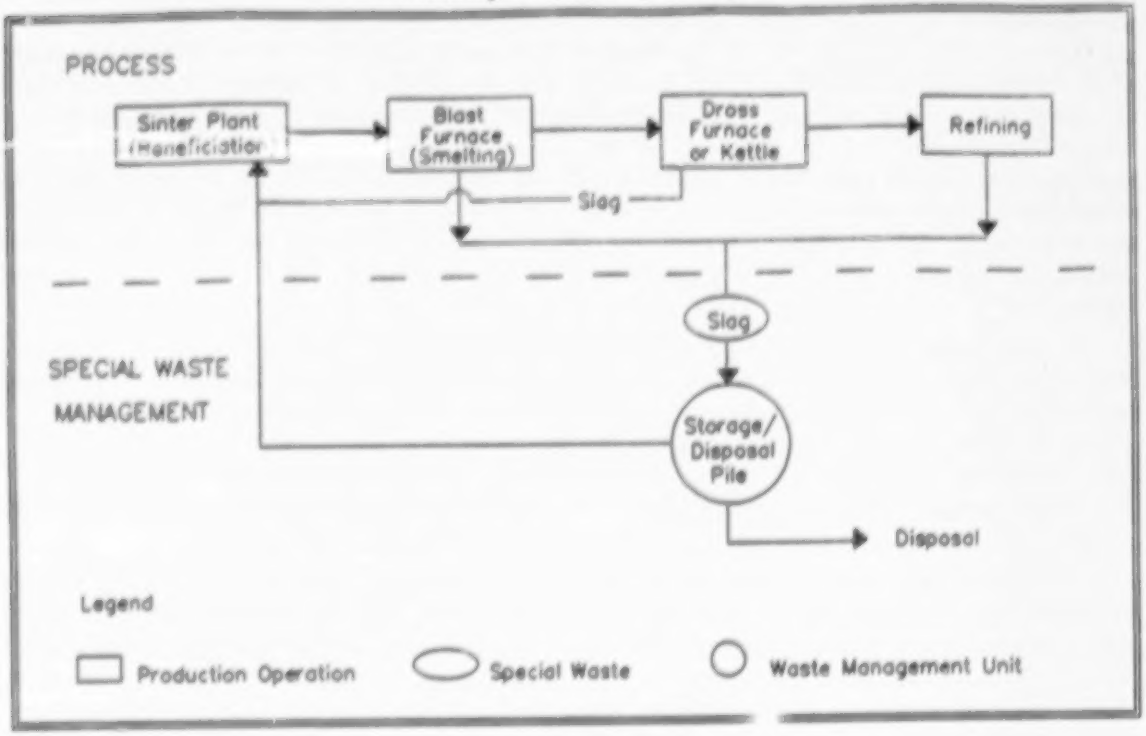
[7] Alan S. Kafka, 1990. "Lead: Tight Market Possible; 121st Annual Survey and Outlook," E&MJ, March, p. 24.

[8] Ibid., p. 23.

[9] Ibid.

[10] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics in the Primary Lead Smelting and Refining. Prepared by PEI Associates for U.S. EPA, Office of Research and Development, Washington, D.C., December.

Exhibit 10-2
Primary Lead Processing


PROCESS
Sinter Plant (Beneficiation)
Blast Furnace (Smelting)
Dross Furnace or Kettle
Refining
Slag
SPECIAL WASTE MANAGEMENT
Slag
Storage/ Disposal Pile
Disposal
Legend
Production Operation
Special Waste
Waste Management Unit

added to the lead, which is then cooled, causing the impurities to rise to the surface and be removed. This refining residue is returned directly to the blast furnace at the Missouri facilities (the three integrated smelter/ refinery operations) and, therefore, is not a solid waste at these facilities. The refinery "slag" generated at the stand-alone refinery in Nebraska is not recycled, but discarded as a solid waste. The refined lead is then cast into ingots.

10.2 Waste Characteristics, Generation, and Current Management Practices

The special mineral processing waste, slag, generated by primary production of lead is generated as a molten mass. The slag may be "hot-dumped" onto a waste pile to form large solid chunks or granulated with a water jet to form fine, sand-sized particles. As reported in the SWMPF Survey and indicated by EPA's sampling results, lead slag is composed primarily of iron and silicon oxides, as well as aluminum and calcium oxides. Other metals may also be present in smaller amounts, including antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, silver, and zinc.[11,12]

Using available data on the composition of lead slag, EPA evaluated whether the slag exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, EPA does not believe the slag is corrosive, reactive, or ignitable, but some slag samples do exhibit the characteristic of EP toxicity. EP leach test

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[11] EPA. 1989. "National Survey of Solid Wastes from Mineral Processing Facilities."

[12] EPA, 1989. "Waste Sampling Data."

concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for lead slag from all five facilities of interest. Of these constituents, arsenic, cadmium, lead, mercury, and selenium concentrations were found to sometimes exceed the EP regulatory levels, with all five facilities having an exceedance for at least one of these constituents. Lead concentrations exceeded the EP level at every facility and in a total of 27 out of 101 samples; the maximum lead concentration exceeded the EP level by a factor of 19. Cadmium concentrations in 7 out of 99 samples (from two facilities) exceeded the EP level by as much as a factor of 8. Arsenic, mercury, and selenium concentrations exceeded the EP level at only one facility, ASARCO in Omaha, NE. However, arsenic and selenium exceeded the level in roughly 27 out of 94 samples from the Omaha facility by as much as a factor of 1,400 and 180, respectively. Mercury concentrations at the Omaha plant exceeded the level in 79 out of 94 samples by as much as a factor of 8. Two of the slag samples that failed the EP toxicity level for lead were also analyzed using the SPLP leach test, and for both of these samples, the concentration of lead measured using the SPLP test was at most 0.7 times the EP toxicity regulatory level.

Blast furnace slag is generated at four facilities; the fifth facility (Omaha, NE) generates waste slags from refining (e.g., exchange kettle and cupola furnace slag) in quantities about two orders of magnitude smaller than the other facilities (actual volume is confidential). For purposes of this report, as established during the reinterpretation rulemaking process, the slag generated at all five facilities, including Omaha's refinery slags, are considered slag from primary lead processing. Refinery slags at the three Missouri facilities, as well as slag from the smelters' dross furnaces, are not included in EPA's analyses, as these slags are directly recycled to the production process and are, therefore, not considered solid wastes.

Only one fully operational lead facility reported non-confidential waste generation data; Doe Run/Herculaneum reported generating 220,000 metric tons of slag in 1988, with a waste-to-product ratio of 0.97. EPA estimates the long term annual waste generation rate for the entire sector to be 469,000 metric tons per year. For the three fully operational facilities with smelter operations (i.e., one standby facility, Doe Run/Boss, and one stand-alone refinery, ASARCO/Omaha, are excluded), the annual generation rate is estimated to be 448,000 metric tons for an average of nearly 150,000 metric tons per facility and a waste-to-product ratio of 1.10. The refinery slag at Omaha is not recycled as is refinery slag at the integrated facilities and is, therefore, considered a waste; the estimated generation rate is 8,000 metric tons per year with a waste-to-product ratio of 0.11.

The predominant waste management practice used at the five lead facilities is to return a majority of the furnace slag (73 and 64 percent at the Doe Run facilities) to the sinter plant and stockpile the remainder. The East Helena smelting facility reported stockpiling all slag on-site; its Omaha refinery reported landfilling all slag off-site. Based on responses to the SWMPF Survey, the total volume of slag accumulated on-site for four lead smelting facilities is approximately 2.7 million metric tons; quantities range from 430,000 to 1,360,000 metric tons at the four smelters. (No slag reportedly accumulates at the Omaha refinery.)

The average dimensions of the slag piles at the four smelting facilities with on-site piles are 30,300 square meters (7.5 acres) of basal area and 10.5 meters (35 feet) of height; on a facility-specific basis the basal areas range from 20,200 to 48,500 square meters and the height from six to 18 meters. Three of the four smelter facilities with large slag piles report that these slag piles are lined with in-situ clay, the fourth is unlined. The Omaha refinery uses three small concrete-lined storage piles to hold slag before shipment off-site; the three piles range from 68 to 230 square meters in basal area and 1.5 to 3 meters in height.

Two facilities reported monitoring ground water around their slag piles, while a third reported monitoring only surface water. One facility reported having run-on/run-off controls; another facility reported using dust suppression but did not describe the practice; and a third facility reported that it collects and manages leachate from the slag pile.

10.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proved. Overall conclusions about the hazards associated with lead slag are provided after these two study factors are discussed.

10.3.1 Risks Associated With Lead Slag

Any potential danger to human health and the environment from lead slag depends on the presence of toxic constituents in the slag that may pose a risk and the potential for exposure to these constituents. These factors are discussed separately below, followed by EPA's risk modeling results for lead slag.

Constituents of Concern

EPA identified chemical constituents in lead slag that may pose a risk by collecting data on the composition of lead slag and evaluating the intrinsic hazard of the slag's chemical constituents.

Data on Lead Slag and Leachate Composition

EPA's characterization of lead slag and its leachate is based on data from three sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); (2) industry responses to a RCRA §3007 request in 1989; and (3) sampling and analysis conducted by EPA's Office of Research and Development (ORD) in 1984. These data provide information on the concentrations of some 20 metals, sulfate, and fluoride in total solids and leach test samples.

These sources provide data on the composition of slag solids at all but one of the five primary lead processing facilities (Boss, MO). Concentrations in total samples of the lead slag are generally within two orders of magnitude for most constituents across all data sources (i.e., EPA and RCRA §3007 responses) and facilities. A notable exception is that concentrations of antimony, arsenic, and silver for the Omaha facility are more than three or four orders of magnitude higher than concentrations of these constituents in slag from any of the other facilities. This difference probably occurs because the Omaha facility, which provided the data, is the only facility that generates refinery slag but no smelter slag.

Data from leach test analyses are available for all five facilities. With a few exceptions, concentrations from leach test analyses of the slag generally are within two orders of magnitude across the data sources (i.e., OSW, ORD, and industry), types of leach tests (EP, SPLP, and TCLP), and facilities.

Process for Identifying Constituents of Concern

As discussed in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if lead slag contains any chemical constituents that may pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to conservative screening criteria and then by evaluating the environmental persistence and mobility of constituents that are present at levels above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which lead slag constituents are released to the environment and migrate to possible exposure points. For example, EPA evaluated the potential for chemicals to pose an inhalation risk by assuming that dust from the slag is blown into the air, when in fact the particle size of most slag is such that it would not become airborne. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and air and surface/ground-water resources (see Exhibit 2-3). Given the conservative (i.e., protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibits 10-3 and 10-4 summarize the frequency with which the chemical constituents of lead slag exceed the risk screening criteria. Data are provided in the exhibits for all constituents that are present in concentrations that exceed a screening criterion.

Exhibit 10-3 identifies constituents in lead slag that are present in concentrations that exceed the screening criteria based on the total sample analysis results from EPA and industry sampling. As shown, eight of the more than 20 constituents analyzed in the slag solids were detected in concentrations that exceed human health screening criteria: arsenic, cadmium, chromium, lead, selenium, antimony, silver, and zinc. All of these constituents are persistent in the environment (i.e., they do not degrade). Arsenic and lead exceeded the criteria most frequently and by the widest margins. For example, both of these constituents exceeded the screening criteria in roughly 90 percent or more of all samples analyzed from at least half of the facilities. Arsenic, lead, chromium, and antimony exceeded the screening criteria by more than a factor of 10 in at least one sample. These exceedances indicate the potential for two types of impacts, as follows:

- Arsenic, lead, antimony, silver, and zinc concentrations may cause adverse health effects if a small quantity of the slag or soil contaminated with the slag is inadvertently ingested over a long period of time, which could occur if public access to the slag piles is not restricted.

Exhibit 10-3
Potential Constituents of Concern in Lead Slag Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Lead	153 / 153	Ingestion	153 / 153	4 / 4
Arsenic	13 / 15	Ingestion* Inhalation*	13 / 15 13 / 15	2 / 4 2 / 4
Antimony	16 / 19	Ingestion	14 / 19	2 / 4
Zinc	81 / 81	Ingestion	2 / 81	2 / 4
Cadmium	8 / 65	Inhalation*	4 / 65	1 / 3
Chromium	1 / 4	Inhalation*	1 / 4	1 / 3
Selenium	1 / 3	Inhalation	1 / 3	1 / 3
Silver	142 / 145	Ingestion	6 / 145	1 / 4

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

Exhibit 10-4
Potential Constituents of Concern in Lead Slag Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Lead	101 / 101	Human Health Resource Damage Aquatic Ecological	72 / 101 94 / 101 61 / 101	5 / 5 5 / 5 5 / 5
Cadmium	97 / 99	Human Health Resource Damage Aquatic Ecological	14 / 99 17 / 99 17 / 99	5 / 5 5 / 5 5 / 5
Arsenic	87 / 96	Human Health* Resource Damage Aquatic Ecological	87 / 96 44 / 96 31 / 96	5 / 5 1 / 5 1 / 5
Zinc	16 / 16	Human Health Resource Damage Aquatic Ecological	5 / 16 5 / 16 13 / 16	3 / 4 3 / 4 4 / 4
Iron	12 / 14	Resource Damage Aquatic Ecological	7 / 14 2 / 14	4 / 4 2 / 4
Cobalt	2 / 3	Resource Damage	2 / 3	2 / 3
Copper	10 / 16	Aquatic Ecological	7 / 16	3 / 5
Manganese	14 / 14	Human Health Resource Damage Aquatic Ecological	1 / 14 6 / 14 1 / 14	1 / 4 4 / 4 1 / 4
Mercury	83 / 94	Human Health Resource Damage Aquatic Ecological	79 / 94 79 / 94 81 / 94	1 / 5 1 / 5 2 / 5
Selenium	79 / 93	Human Health Resource Damage Aquatic Ecological	25 / 92 46 / 92 26 / 92	1 / 5 1 / 5 1 / 5
Silver	79 / 94	Aquatic Ecological	9 / 94	1 / 5
Antimony	74 / 76	Human Health Aquatic Ecological	64 / 76 10 / 76	1 / 4 1 / 4

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

- Selenium, arsenic, chromium, and cadmium may pose a health threat if slag dust is blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter. However, as discussed in more detail in the section on Air Release, Transport, and Exposure Potential, the particle size distribution of lead slag and the distance to potential receptors significantly limits the potential for such large exposures to dust from slag piles.

Lead concentrations in 26 of 153 samples of the slag solids (from two of four facilities) also exceeded the air resource damage screening criterion. This suggests that lead concentrations could be high enough to cause an exceedance of the National Ambient Air Quality Standard for lead if slag dust is blown into the air in a concentration that equals the air quality standard for particulates matter. Again, the extent to which dust is actually blown into the air from slag piles is limited by the relatively large size of lead slag particles.

Exhibit 10-4 identifies the constituents that exceed the screening criteria based on leach test data from EPA and industry.[13] As shown, 12 constituents were detected in lead slag leachate in concentrations that exceed risk screening criteria for water-based release and exposure pathways. All of these constituents are inorganics that do not degrade in the environment. In general, arsenic, lead, and mercury exceeded the criteria most frequently (in at least 90 percent of the samples from at least half of the facilities). The arsenic and lead concentrations also exceeded the screening criteria by the widest margins (up to a factor of 1,000 or more). As discussed previously, arsenic, lead, cadmium, mercury, and selenium were also measured in EP leachate in concentrations that exceeded the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Arsenic, cadmium, lead, selenium, antimony, zinc, and mercury concentrations in the slag leachate may pose a health risk if the leachate is released to ground water, diluted by a factor of 10 during migration to a downgradient drinking water well, and ingested over a long period of time.
- If the slag leachate is released to ground or surface water, arsenic, cadmium, lead, selenium, cobalt, iron, manganese, zinc, and mercury concentrations could render the water unsuitable for a variety of uses (e.g., irrigation, direct human consumption of the water, or human consumption of fish that live in affected water bodies).
- Concentrations of arsenic, cadmium, lead, selenium, antimony, silver, copper, iron, zinc, and mercury in the slag leachate may present a threat to aquatic organisms if the leachate migrates (with a 100-fold dilution) to surface waters.

These exceedances, by themselves, do not prove that the slag poses a significant risk, but rather indicate that the slag may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for this waste to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the slag.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of lead slag as it was generated and managed at the five active facilities in 1988. Lead slag is primarily disposed on-site (i.e., at four of five facilities) and the slag is not currently used off-site, although several options for off-site utilization are available (see Section 10.5). This analysis does not assess the hazards of off-site disposal of slag from the Omaha facility because of a lack of data on the management practices and environmental conditions of the off-site disposal facility. Instead, this analysis evaluates hazards posed by the storage of slag at the Omaha facility prior to its transport off-site.

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[13] For the purpose of this analysis, comparison of leach test data to screening criteria rely on EP leach test results. Results from the SPLP leach test identified the same constituents of concern as the EP leach test, though the results from the two leach tests differ somewhat in terms of the magnitude with which constituent concentrations exceed the screening criteria.

The following analysis also does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data adequate to predict future conditions.

Ground-Water Release, Transport, and Exposure Potential

As discussed in the preceding section, EPA and industry test data show that several constituents are capable of leaching from lead slag in concentrations above the screening criteria. However, considering the existing slag management practices and neutral pH conditions that are expected, only arsenic, cadmium, selenium, cobalt, and mercury are likely to be mobile in ground water if released. Exhibit 10-5 summarizes the key factors at each lead facility that affect the potential for these constituents to be released into ground water and cause impacts through that pathway.

Releases to ground water at the East Helena, MT smelter, the Glover, MO facility, and the Boss, MO facility are considered possible because ground-water monitoring near the slag piles at each of these sites has identified contamination that may be attributable to the slag. (See the damage case study findings in Section 10.3.2 for more discussion of this observed contamination.) The releases at Glover and Boss may have been facilitated by the karst and dolomite that underlie these sites. These earth materials are prone to develop solution cavities that can permit the ready transport of ground-water contaminants. The East Helena facility is in an area that has a very low natural net recharge to ground water, less than 1 cm/yr. However, any ground-water contamination that can be attributed to the slag pile at this site could have been caused by the former practice of sprinkling contaminated wastewater on the pile to control dust. There are also wastewater ponds near the slag pile at East Helena that appear to be primary contributors to ground-water contamination at this site. Ground water in the vicinity of each plant is used as a drinking water supply, and residences that could have drinking water wells are located only 180 meters downgradient from the East Helena smelter and 980 meters downgradient of the Boss facility. The distance between the slag pile at Glover and the nearest downgradient residence that could have a well is not known, but the nearest property boundary in a downgradient direction (where the ground water conceivably could be withdrawn for drinking) appears to be at least 600 meters from the pile.

Although ground-water monitoring data are not available for the Herculaneum facility and the Omaha refinery, the potential for releases to ground water and subsequent exposures at these sites is reduced by a number of site-specific factors.

- The on-site slag pile at the Herculaneum facility is underlain by in-situ clay. The uppermost useable aquifer is deep, roughly 80 meters below the land surface, and the primary earth materials separating the slag pile from this useable aquifer are relatively impermeable clays and silts. The net recharge in the area of the Herculaneum facility is very low, about 2 cm/yr, meaning that relatively little precipitation is available to seep through the pile and carry slag contaminants to the subsurface. Ground water in the area is used as a municipal drinking water supply, but there currently are no downgradient drinking water wells within 1,600 meters (1 mile).
- Ground water beneath the Omaha refinery is very shallow, only 2 meters beneath the land surface. However, release from the three, relatively small slag piles to ground water is limited by management practices (i.e., use of concrete pits for slag storage) and a low net recharge (5 cm/yr). There are no known uses of ground water in the area, and there are no downgradient drinking water wells within 1,600 meters (1 mile) of the site.

If leachate from the slag piles at the Herculaneum and Omaha facilities did seep into ground water, it could restrict potential ground-water uses in the future, but it would not pose a current health threat considering the large distances to existing drinking water wells.

Exhibit 10-5
Summary of Release, Transport, and Exposure Potential for Lead Slag

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
BOSS	**Ground Water**: Releases limited by in-situ clay liner, leachate collection system, large depth to useable aquifer (45 m), impermeable subsurface, and low net recharge (5 cm/yr); contamination that may be attributable to the slag pile has been detected, although this contamination may have been caused by two unlined wastewater impoundments next to the pile; nearest downgradient drinking water well is 980 meters away. **Surface Water**: High annual precipitation (98 cm), impermeable subsurface, and steeply sloped land (6-12%) create the potential for surface erosion; run-off from the slag pile, however, is collected and treated; Crooked Creek is located 1,100 m away; no consumptive uses of creek within 24 km, but low flow (16 mgd) indicates little potential for dilution and possible aquatic ecological risks. **Air**: Releases not controlled by dust suppression; wind erosion and dumping operations could lead to potential inhalation exposures at the nearest residences located 915 m from facility; 1,800 people living within 8 km (5 miles).	Located in a National Forest
HERCULANEUM	**Ground Water**: Releases limited by in-situ clay liner, large depth to useable aquifer (80 m), impermeable subsurface, and low net recharge (2 cm/yr); no drinking water wells within 1.6 km (1 mile) downgradient. **Surface Water**: High annual precipitation (94 cm), impermeable subsurface, and moderate topographic slope (up to 6%) create potential for surface erosion; Mississippi River is close (within 90 m), but its very large flow (100,000 mgd) yields significant dilution; no consumptive uses of river within 24 km. **Air**: Releases not controlled by dust suppression; wind erosion and slag dumping could lead to airborne dust and inhalation exposures at the nearest residence just 15 m from facility; 25,000 people living within 8 km (5 miles).	Located in a 100-year floodplain and within 1.6 km of a wetland
EAST HELENA	**Ground Water**: Pile is not lined, useable aquifer is shallow (4 m deep), and subsurface is permeable; although net recharge is low (< 1 cm/yr), former practice of sprinkling pile with wastewater for dust suppression may have led to ground-water contamination; observed contamination is mainly attributed to two unlined impoundments, not the slag pile; potential drinking water exposure at residence as close as 180 m downgradient. **Surface Water**: Surface erosion limited by low annual precipitation (29 cm) and gentle topographic slope (< 2%); Prickly Pear Creek located just 55 m downgradient; although no consumptive uses of creek within 24 km, the creek's low flow (26 mgd) allows little dilution and possible aquatic ecological risks. **Air**: Releases not controlled by dust suppression, and monitoring has detected exceedance of air quality standard for lead; potential inhalation exposures at residences located as close as 180 m from facility and potential food chain exposures through deposition of particulate matter on surrounding agricultural fields; approximately 12,000 people living within 8 km (5 miles).	Located in a 100-year floodplain, a wetland, and a fault zone

Exhibit 10-5 (cont'd)
Summary of Release, Transport, and Exposure Potential for Lead Slag

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
OMAHA	Ground Water: Although ground water shallow (2 m deep), releases limited by concrete liners and low net recharge (5 cm/yr); no drinking water wells within 1.6 km (1 mile) downgradient. Surface Water: Moderate annual precipitation (76 cm), low net recharge, moderate topographic slope (up to 6%), and short distance to Missouri River (60 m) create surface water contamination potential; however, river's large flow (18,000 mgd) provides for significant dilution and there are no consumptive uses within 24 km. Air: Releases controlled by dust suppression, decreasing release potential; if airborne releases, potential inhalation exposures at residences located as close as 1,100 m from facility; roughly 224,000 people living within 8 km (5 miles).	Located in a 100-year floodplain and a fault zone, and within 1.6 km of a wetland
GLOVER	Ground Water: Although releases limited by in-situ clay liner, stormwater run-on/run-off controls, impermeable subsurface, and low net recharge, monitoring has identified ground-water contamination; ground water is used for drinking in the area, but the nearest property boundary in downgradient direction (where water could be withdrawn) is 600 m from slag pile. Surface Water: Existing ground-water contamination, high annual precipitation (105 cm) and moderate distance to Scroggins Branch that discharges into Big Creek (244 m) create contamination potential; however, run-off from the slag pile is now collected and treated prior to discharge; creek not used for consumptive uses within 24 km, but its moderate flow (80 mgd) allows only moderate dilution and possible aquatic ecological risks; monitoring has identified contamination possibly attributable to slag pile. Air: Releases not controlled by dust suppression; wind erosion and slag dumping could lead to airborne dust and inhalation exposures at residences as close as 60 m from facility; only 840 people live within 8 km (5 miles).	Located in a National Forest and an area of karst terrane

Surface Water Release, Transport, and Exposure Potential

The primary pathways for lead slag contaminants to enter surface waters are migration in a leached form through ground water that discharges to surface water, and direct overland run-off via storm water erosion either in a leached form or in the form of solid particles. The high concentrations of several constituents detected in slag leachate tests confirm that the potential exists for slag contaminants to migrate into surface water in a leached form. The physical form of the slag, however, being relatively large particles ranging from sand-size (0.2 to 2 mm) to boulders (larger than 0.3 meters or 12 inches), should help limit the overland run-off of slag solids. Only particles that are 0.1 mm or less in size tend to be appreciably erodible, and only a very small fraction of the slag solids are expected to be in this size range.

Exhibit 10-5 summarizes the characteristics of each of the five lead facilities that affect the surface water release, transport, and exposure potential of lead slag. Based on an analysis of these characteristics, it is possible for slag contaminants to be released to surface water at all five facilities. In fact, an inspection report indicates that the slag pile at the Boss facility may be a source of surface water contamination and contaminated run-off that may discharge into surface water has been observed at the Glover and East Helena facilities (see the damage case study findings discussion below). All of the slag piles are located within 1,100 meters of a river or creek, with Herculaneum, East Helena, and Omaha being within 100 meters of a water body. The Herculaneum, East Helena, and Glover facilities are also within 100-year floodplains, and although remote, the possibility of large releases from the slag piles caused by floods at these sites cannot be dismissed. In addition, all but the East Helena smelter are located in areas with relatively high annual precipitation (76 to 105 cm/yr) that could cause significant run-off. The only facilities that use storm water run-on/run-off controls at their slag piles are the Boss and Glover facilities.

Although there appears to be a potential for release at all lead facilities, the potential for significant surface water contamination appears to be greatest at the Boss, East Helena, and Glover facilities (depending on the efficiency of the storm water run-on/run-off controls at Boss and Glover). The creeks/rivers near these facilities are relatively small to moderate in size, with an average annual flow that ranges from 16 to 81 mgd. These relatively low flows provide a limited dilution capacity compared to that provided by rivers near Herculaneum and Omaha, which have an average annual flow of 100,000 mgd and 18,000 mgd, respectively. These large flows should allow for significant dilution of any contamination released from the slag piles. Furthermore, none of the creeks or rivers located near the lead facilities are currently used for drinking water or any other consumptive purpose within 24 km (15 miles). Therefore, any contamination originating from the slag piles would not pose a current health risk through surface water, though it could pose an aquatic ecological risk and render the water less suitable for potential future uses.

Air Release, Transport, and Exposure Potential

Because the constituents that exceed the screening criteria are nonvolatile, lead slag contaminants can only be released to air in the form of dust particles. The particles can be either blown into the air by wind or suspended in air by slag dumping and loading operations. Factors that affect the potential for such airborne releases include the particle size of lead slag, the height and exposed surface area of the slag piles, the slag moisture content, the use of dust suppression controls, and local wind speeds. The potential for exposure to airborne dust depends on the proximity of the slag piles to people and agricultural lands.

The relatively large size of lead slag particles limits the potential for release of airborne dust. In general, particles that are $\leq$ 100 μm (0.1 mm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 μm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 μm in diameter are respirable. As mentioned previously, lead slag particles range from sand-size (0.2 to 2 mm) to boulders (larger than 30 cm). Therefore, the vast majority of the slag should not be suspendable, transportable, or respirable. It is likely that only a very small fraction of the slag will be weathered and aged into smaller particles that can be suspended in air and cause airborne exposure and related impacts.

The height and exposed area of the slag piles, the slag moisture content, the use of dust suppression controls, wind speeds, and the proximity of the slag pile to people vary on a site-specific basis, as follows:

- At the Boss facility, the slag pile is approximately 20,000 square meters (5 acres) in area and 6 m high. The pile is not covered with either vegetation or a synthetic material. The facility does not use any dust suppression controls, such as sprinkling water on the pile, and the number of days with rain, which may suppress dust, is small (73 days/yr). As a result, the surface slag is expected to be dry most of the time. Although short term gusts of strong winds inevitably occur, average wind speeds range from 2.3 to 4 m/s, which are strong enough to produce wind erosion of any fine particles on the surface of the slag pile. The nearest residence in a predominant wind direction is approximately 915 meters away and there are roughly 1,800 people living within 8 km (5 miles).
- The slag pile at the Herculaneum facility covers an area of 49,000 square meters (12 acres), is 8 m high, and is uncovered. The slag is expected to be dry most of the time because no dust suppression sprinkling is conducted and the number of days with precipitation is small (85 days/yr). Average wind speeds range from 3.6 to 5.5 m/s,

although there are short-term gusts of stronger winds. The nearest residence is very close, only 15 meters downwind, and the surrounding population within 8 km is large, approximately 25,000 people.

- The slag pile at the East Helena facility covers an area of 20,000 square meters (5 acres), is 11 meters high, and is uncovered. Although the pile is not currently watered for the purpose of dust suppression, there is a relatively large number of days that have a small amount of precipitation (155 days/yr) that should help keep the slag moist part of the time. Average wind speeds range from 2.3 to 4.7 m/s, although stronger winds occur on a short term basis. Ambient air quality monitoring in the vicinity of the pile has identified an exceedance of the air quality standard for lead, and plant personnel have indicated that the slag pile is a contributor to this contamination. The nearest residences are located 180 meters downwind and there are roughly 12,000 people that live within 8 km (5 miles). In addition, there is a potential for food chain exposures caused by the deposition of airborne particulates on agricultural fields that are near the facility.
- At the Omaha facility, there are three relatively small slag piles that are all less than 3 m high and cover a combined area of less than 12,000 square meters (3 acres). Although there is a small number of days of precipitation to help keep dust down (98 days/yr), the facility practices dust suppression. The nearest residence in a predominant wind direction is located 1,100 meters downwind. The plant is located in a densely populated area, with approximately 224,000 people living within 8 km.
- The slag pile at Glover covers 32,000 square meters (8 acres), is 18 m high, and is uncovered. The slag is expected to be dry most of the time because no dust suppression sprinkling is conducted and the number of days with precipitation is small (80 days/yr). Considering the average wind speeds (2.6 to 4.4 m/s) and the potential for short-term gusts of stronger winds, wind erosion is possible. Although the nearest residence in a predominant wind direction is only 60 meters downwind, the plant is located in a sparsely populated area: 840 people live within 8 km.

In summary, slag particles are generally quite large and only a very small fraction of the lead slag has the potential to be suspended in air and transported to downwind exposure points at each of the lead facilities. The slag piles, however, are generally large, tall, and uncovered, presenting a large exposed area from which dust can escape. Wind speeds in the vicinity of each facility are sufficient to cause windblown dust, and dust may also be suspended at each site by slag loading and unloading. The slag also is expected to be dry most of the time, which facilitates dusting. In addition, all five facilities have individuals living within 1.6 km (one mile) that could be exposed to airborne particles released from the slag piles.

Based on the evaluation of the lead slag composition presented above, constituents that could pose a health threat by dust inhalation include arsenic, cadmium, chromium, and selenium. The particle size distribution of lead slag, however, significantly limits the potential for constituent entrainment and transport to potential receptors. Among the five primary lead facilities, the potential for exposure to airborne contaminants appears greatest at the Herculaneum facility because of the close proximity to residences. The potential for airborne exposures appears lowest at Omaha because of the relatively small size of the slag piles and the dust suppression controls reportedly used at that site.

Proximity to Sensitive Environments

As summarized in Exhibit 10-5, all of the lead facilities are located in either a vulnerable environment or an environment that has high resource value. In particular:

- The Boss and Glover facilities are located in the Mark Twain National Forest in the Missouri Ozarks. The existing contamination that is potentially attributable to lead slag at these sites could make the forest less desirable to use for recreational purposes.

- The Herculaneum, East Helena, and Glover facilities are all located in 100-year floodplains, which creates the potential for large, episodic releases from the on-site slag piles due to flood events.
- The Herculaneum, East Helena, and Glover facilities are also located either in or within 1.6 km (one mile) of a wetland (defined here to include swamps, marshes, bogs, and other similar areas). Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural waters, provide flood and storm damage protection, and afford a number of other benefits.
- The East Helena and Glover facilities are located in fault zones. This creates the potential for earthquake damage to containment systems for slag piles at these sites.
- The Glover facility is located in an area of karst terrane, characterized by sink holes and underground cavities developed by the action of water in soluble rock (such as limestone or dolomite). Solution cavities that may exist in the bedrock at this site could permit any ground-water contamination originating from the slag pile to migrate in a largely unattenuated and undiluted fashion.

Risk Modeling

Based on the preceding analysis of the intrinsic hazard of lead slag and the potential for slag contaminants to be released into the environment, the Agency ranked lead slag as having a relatively high potential to cause risk to human health and the environment (compared to the other mineral processing wastes studied in this report). Therefore, EPA used the model "Multimedia Soils" (MMSOILS) to quantify the risks associated with the lead slag contaminants, facilities, and release and exposure pathways that appear to pose the greatest concern.

Ground-Water Risks

EPA modeled potential releases to ground water from the on-site slag piles at all five facilities of interest. Using site-specific data with respect to contaminant concentrations, slag quantities, existing management practices, and hydrogeologic characteristics, the Agency predicted the concentrations of arsenic, cadmium, selenium, cobalt, mercury, and lead in ground water at the following locations downgradient from the slag piles: the property boundary, the nearest existing residence that could have a private drinking water well, the nearest surface water body, and, to provide a common frame of reference across the facilities, the distances of 50, 500, and/or 1,000 meters downgradient. EPA used median constituent concentrations measured with the EP leach test as inputs to the model. For each constituent, the Agency compared the predicted concentrations at the modeled locations to EPA-approved benchmarks for human health protection, drinking water maximum contaminant levels (MCLs), and National Academy of Sciences (NAS) recommended guidelines for irrigation and livestock waters.

At the facilities in Boss, MO, Herculaneum, MO, and Omaha, NE, the predicted contaminant concentrations at each downgradient distance were two orders of magnitude or more below the various criteria. The predicted concentrations of arsenic at each of the downgradient locations were so small that, if the water was ingested, it would pose a lifetime cancer risk of less than $1x10^{-10}$ (i.e., the chance of getting cancer would be less than one in ten billion over a 70-year lifetime). In many cases, it was predicted that the contaminants would not migrate to the water table within the modeling horizon (200 years). Due to the low levels of precipitation infiltrating through the piles and into ground water, the depths to ground water, the low permeability of the underlying earth materials, and the tendency of the contaminants to bind to soil, many of the contaminants were predicted to remain adsorbed in the unsaturated zone at these sites for more than 200 years.

The same overall results were predicted for the facilities in Glover, MO and East Helena, MT, with the following exceptions:

- At the Glover facility, predicted concentrations of arsenic in ground water as far as 125 meters from the slag pile, but still on plant property, could pose a lifetime cancer risk of $4x10^{-7}$. Predicted arsenic concentrations at the plant boundary (estimated to be about 600 meters downgradient) would yield cancer risks of less than $1x10^{-10}$. EPA has assumed here that the slag pile and adjacent areas in the downgradient direction are not underlain by karst. If, however, the subsurface of these areas do contain karst, actual ground-water contaminant concentrations could be higher than EPA's risk modeling exercise has indicated.
- Also at the Glover facility, the predicted concentrations of cobalt in ground water roughly 250 meters downgradient from the slag pile exceeded the NAS irrigation guideline by as much as a factor of 7. Cobalt concentrations at the plant boundary and beyond were estimated to be below this threshold. If water with cobalt concentrations in excess of the NAS guideline is used continuously for irrigation, it could be toxic to tomatoes, peas, beans, oats, rye, wheat, barley, and corn.
- Similarly, at the smelter in East Helena, MT, the predicted concentrations of cobalt in ground water exceeded the NAS irrigation guideline by as much as a factor of 1.5 as far downgradient as the property boundary (about 55 meters from the slag pile).

This cobalt contamination at the Glover and East Helena facilities is likely to have little practical significance at present. Along with the fact that the contamination at Glover is likely to be confined to the plant property, the land surrounding the Glover facility is largely forested and does not appear to be used for agricultural purposes close to the site. Although the land surrounding the East Helena smelter is used for agriculture, a portion of the slag pile is adjacent to Prickly Pear Creek and any cobalt contamination in the ground water may discharge into the creek and be diluted somewhat, rather than extracted directly from the ground and used for irrigation.

Surface Water Risks

To evaluate surface water risks, EPA estimated the concentrations of lead slag contaminants in nearby rivers and creeks after the contaminants have been fully mixed in the water's flow. EPA considered in this analysis the annual (chronic) loading of contaminants to rivers/creeks via ground-water seepage and erosion from the slag piles, but did not consider larger short-term releases, such as those associated with large storms, that could result in higher concentrations that last for shorter durations. The Agency predicted the surface water concentrations of the following lead slag constituents: antimony, arsenic, cadmium, cobalt, iron, lead, manganese, mercury, selenium, silver, and zinc. For each constituent, the Agency compared the predicted concentrations to available EPA-approved benchmarks for human health protection, drinking water MCLs, freshwater ambient water quality criteria (AWQCs) for chronic exposures, and NAS recommended guidelines for irrigation and livestock waters. Note that the methodology used here does not account for removal of pollutants via drinking water treatment, and thus overstates risk through this pathway. In addition, the Agency conservatively modeled the slag piles at the Boss and Glover facilities as if they were not equiped with stormwater run-on/run-off controls.

For the facilities located in Herculaneum, MO and Omaha, NE, the predicted concentrations of all contaminants were at least two orders of magnitude below the various criteria. The very large flows of the Mississippi and Missouri Rivers adjacent to these facilities were predicted to effectively dilute any contaminants released from the on-site slag piles.

The surface water concentrations of most contaminants were also estimated to be one or two orders of magnitude below the various criteria in the creeks near the Boss, East Helena, and Glover facilities. However, the predicted concentrations of arsenic, lead, iron, manganese, and zinc exceeded at least one criterion at each of these facilities. Essentially all of this contamination was estimated to be caused by erosion of fine particles from the slag piles, rather than seepage of contaminants into ground water that discharges into surface water. As shown in Exhibit 10-6:

- Estimated arsenic concentrations in the creeks nearest to the Boss, East Helena, and Glover facilities would cause lifetime cancer risks of $1x10^{-5}$ to $5x10^{-5}$ if ingested (i.e., the chance of getting cancer would be at least one in 100,000 over a 70-year lifetime). These concentrations are well below the MCL, however.
- The estimated concentrations of lead in Crooked Creek near the Boss facility and Big Creek near the Glover facility exceed the noncancer effect threshold by roughly a factor of three. Long-term ingestion of water with this lead concentration could cause neurotoxicological effects.
- The estimated concentrations of iron, lead, and manganese in the creeks near the Boss and Glover facilities also exceed the drinking water MCLs for these constituents. In addition to the adverse neurotoxicologic effects of lead, such concentrations of iron and manganese could cause objectionable tastes and cause stains.
- The estimated concentration of lead in the creeks near all three facilities and the estimated concentration of zinc in the creeks near the Boss and Glover facilities exceed the AWQC for these constituents. Chronic exposures to these contaminant concentrations could adversely affect the health of any aquatic organisms living in the creeks. Depending on the efficiency of the stormwater run-on/run-off controls at the Boss and Glover facilities, the slag piles at these sites are likely to cause significantly less contamination than was predicted.

Of the constituents that were modeled, only mercury and selenium are recognized as having the potential to biomagnify (concentrate in the tissues of organisms higher in the food chain). EPA's predicted concentrations of mercury, however, were well below the AWQC and adverse effects due to biomagnification are not expected. Although the selenium concentrations were also predicted to be below the AWQC, the potential for selenium to biomagnify and cause adverse effects to wildlife at higher trophic levels cannot be ruled out (the selenium AWQC does not account for biomagnification). Mercury, cadmium, selenium, zinc, and, to a lesser extent, arsenic may bioaccumulate in the tissue of freshwater fish that may be ingested by humans. However, even if an individual ingests 6.5 grams of fish[14] from the contaminated water every day of the year for 70 years, cancer risks would be less than $7 x 10^{-7}$ and the doses of noncarcinogens would be below adverse effect thresholds.

As discussed in the preceding section on potential release, transport, and exposure pathways, none of the creeks near the Boss, East Helena, and Glover facilities are currently used as drinking water supplies within 24 km of the sites. Therefore, the predicted contaminant concentrations in these creeks are not expected to pose a current drinking water threat, but may present a hazard if the waters are ever used for drinking in the future.

Air Risks

EPA modeled the release and inhalation of windblown dust from the slag piles at four of the five facilities: Glover, East Helena, Boss, and Herculaneum. At each facility, the Agency predicted risks caused by windblown arsenic, cadmium, chromium, selenium, and lead, which are the primary slag constituents that exceed the screening criteria through the air pathway based on the preceding analysis of the slag's composition. The Agency did not predict air pathway risks at the Omaha facility because that facility suppresses dust from the on-site slag piles. In general, the Agency's modeling approach was very conservative (i.e., tending to overpredict air pathway risks) because it was based on the assumption that there is an unlimited reservoir of fine particles that can be blown into the air from lead slag piles. As discussed

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[14] This is a typical daily fish intake averaged over a year (EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989).

Exhibit 10-6
Surface Water Risk Estimates for Lead Slag[a]

Parameter/Constituent	Facility Location[b]		
	Boss, MO	East Helena, MT	Glover, MO
Distance to water	1,097 m	55 m	244 m
Cancer Risk			
Arsenic	5×10^{-5}	1×10^{-5}	1×10^{-5}
Ratio of Concentration to Noncancer Threshold			
Lead	2.9	0.2	2.6
Ratio of Concentration to MCLs[c]			
Iron	2.1	0.3	1.8
Lead	12.4	0.7	11.2
Manganese	1.8	0.1	1.5
Ratio of Concentration to AWQCs[d]			
Lead	19.3	1.1	17.5
Zinc	3.8	0.5	3.3

(a) Values in this exhibit are based on constituent concentrations after complete mixing in the receiving water body. Results are provided for only those constituents that were predicted to exceed a criter The predicted concentrations of all other constituents that were modeled (cadmium, cobalt, mercury, selenium, silve and antimony) were one to two orders of magnitude below the criteria.

(b) The prediced surface water concentrations of all constituents that were modeled were at least two orders of magnitude below the criteria at the facilities in Herculaneum, MO and Omaha, NE. EPA conservatively modeled the slag piles at the Boss and Glover facilities as if they were not equipped with stormwater run-on/run-off controls. Depending on the efficiency of these control systems, the slag piles at these sites are likely to cause significantly less contamination than was predicted.

(c) The proposed revised primary maximum contaminant level for lead, and the secondary maximum contaminant levels for iron and manganese.

(d) The freshwater ambient water quality criteria for chronic exposures, designed to protect the health of aquatic organisms.

previously, lead slag actually has limited wind erosion potential, as it consists of a mixture of small particles and large chunks that consume much of the wind's shear stress.

Even with this conservative approach, risks caused by the inhalation of dust from lead slag piles were predicted to be very low at all four facilities. In particular, at the nearest residences in predominant wind directions (the maximum exposed individual) at each site:[15]

- The total lifetime cancer risk caused by the inhalation of arsenic, cadmium, and chromium (conservatively assumed to exist in the carcinogenic hexavalent form) ranges from $<1\text{x}10^{-10}$ at the Boss, MO facility to $<9\text{x}10^{-7}$ at the facility in Herculaneum, MO. The highest cancer risks were predicted at the Herculaneum facility because the maximum exposed individual at this site lives only 15 meters from the slag pile.

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[15] The approximate distance from the slag pile to the maximum exposed individual is 915 meters at the Boss facility, 15 meters at the Herculaneum facility, 180 meters at the East Helena facility, and 60 meters at the Glover facility.

- The predicted concentrations of selenium in the air were more than two orders of magnitude below the threshold concentration that is associated with dermatitis and gastrointestinal tract disturbances.
- The predicted concentrations of lead in the air were more than two orders of magnitude below the National Ambient Air Quality Standard.

EPA also estimated inhalation risks in the middle of population centers near the East Helena and Herculaneum facilities (the Glover and Boss facilities are located in sparsely populated areas with roughly 840 and 1,800 people currently living within 8 km (5 miles) of each of these plants, respectively). Approximately 7,700 people live between 1.6 km and 8 km to the west of the East Helena facility, and EPA's estimate of cancer risk caused by the inhalation of lead slag dust at the center of this population area is approximately $5x10^{-10}$. Similarly, roughly 12,000 people live between 1.6 km and 8 km to the south and south-southwest of the Herculaneum facility; the inhalation of lead slag dust in the middle of this population center poses a cancer risk of less than $7x10^{-9}$. The predicted concentrations of selenium and lead in the air at the population centers near both of these facilities were also well below the hazard criteria, as they were at the nearest residences.

10.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the environmental performance of lead slag waste management practices at all four active lead smelters: ASARCO in East Helena, Montana; ASARCO in Glover, Missouri; Doe Run in Herculaneum, Missouri; and Doe Run's Buick smelter in Boss, Missouri. No documented environmental damages associated with the slag piles were identified for the Herculaneum facility, based on the limited monitoring data available for this site. The two ASARCO facilities and the Boss, Missouri facility were found to have documented exceedances of drinking water standards or water quality criteria in ground or surface waters that have been caused at least in part by the lead slag piles at the facilities. Two additional facilities, ASARCO in El Paso, Texas, and Midvale Slag in Midvale, Utah, have combined lead, copper, and zinc slags on site which have resulted in documented environmental damages. Each of the six sites identified with documented damages is discussed below.

ASARCO, East Helena, Montana

This facility, which started operation in 1888, is located immediately adjacent to the town of East Helena, five miles east of Helena, and covers approximately 32 hectares (80 acres). Numerous private wells surrounding this facility are used as sources of drinking water.[16]

The smelter currently produces lead bullion that is shipped to the ASARCO facility in Omaha, where it is further refined. An on-site zinc fuming operation further refined the lead slag from 1927 until 1982. Through this process, zinc was recovered by injecting air into the molten lead slag and recovering zinc oxide. ASARCO suspended operation of the zinc fuming department in 1982 because it was uneconomical. More than six million tons of fumed slag has been placed on 11 hectares (28 acres) along the northeastern boundary of the plant property. Beginning in 1982, ASARCO placed the unfumed slag in a segregated area adjacent to the fumed slag piles. The 300,000 tons of unfumed slag covers about 18,000 square meters (4.5 acres). Up until January 1989, the unfumed slag was poured in molten form on a slag pile adjacent to the plant. ASARCO currently air cools the slag in steel vessels before disposal.

Initial evidence of contamination originating from the slag piles was found in 1979, when a Montana Department of Health and Environmental Sciences (MDHES) inspector reported water seeps flowing from the slag piles into an adjacent creek. The inspector described the seeps as "a grayish steaming flow discharging to the creek at an estimated 2 cfs." The inspector also noted that the discharge "appeared to be flowing from under the slag piles at ASARCO." As shown in Exhibit 10-7, these seeps were found to contain elevated levels

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[16] ASARCO. 1986. Draft Report on Water Resources Monitoring - Asarco East Helena Plant.

Exhibit 10-7
Results of Surface Water Sampling and Analysis
ASARCO, East Helena, Montana

Sampling Date		Parameter (mg/L)					
		Pb	As	Cu	Zn	Cd	Mn
ABOVE SLAG PILE							
10/24/80	Prickley Pear Creek Above ASARCO Dam	<0.03	0.20(a)	0.01	0.29	<.005	0.34
10/23/80	Prickley Pear Creek Above Green Discharge	<0.05	0.20	0.01	0.34	0.01	0.25
10/23/80	Prickley Pear Creek Below Green Discharge	0.05	2.02	0.01	0.37	0.04	0.27
10/24/80	Prickley Pear Creek Below Green Discharge	<0.05	0.075	0.01	0.34	<0.005	0.29
DISCHARGE FROM SLAG PILE							
02/19/80	Seep from Slag Pile	0.07	80	0.04	0.06	–	0.26
03/05/80	Seep from Slag Pile	<0.05	70	0.01	0.04	–	0.18
03/11/80	Seep from Slag Pile	0.05	75	0.11	0.08	<0.005	0.24
BELOW SLAG PILE SEEPS							
10/15/79	Prickley Pear Creek Above Main Discharge	<0.05	0.04	0.02	0.15	0.004	–
10/31/79	Prickley Pear Creek Above Main Discharge	<0.05	0.08	0.01	0.11	<0.005	–
BELOW SLAG PILE AND MAIN FACILITY DISCHARGE							
11/01/79	Prickley Pear Creek Below both Discharge Points	0.12	3.65	0.02	0.20	0.03	–
11/01/79	Prickley Pear Creek Below both Discharge Points	0.12	3.65	0.02	0.20	0.03	–
BELOW SLAG PILE AND BOTH FACILITY DISCHARGES							
10/15/79	Prickly Pear Creek Below Main Discharge	<0.05	0.04	0.01	0.16	0.004	–
10/31/79	Prickly Pear Creek Below Main Discharge	<0.05	0.90	0.01	0.14	0.01	–

(a) The concentrations which are underlined represent exceedances of the MCL, based on the National Primary Drinking Water Regulations.

of arsenic and lead. Samples of the seep water showed arsenic concentrations from 70 to 80 mg/L. The MDHES states that years of mining in the Prickley Creek headwaters has yielded arsenic levels above MCLs upstream from the plant site.[17] Monitoring data from the creek did not show a definite increase in in-stream concentrations of arsenic. As reported by MDHES, the seeps were caused by ASARCO's practice of spraying the pile with contaminated watewater for the purpose of dust control. The discharge to the creek from the seeps was eliminated when ASARCO ceased sprinkling the slag with wastewater.[18]

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[17] Montana Department of Health and Environmental Sciences, 1990. Letter from G. Mullen to K. McCarthy, ICF Incorporated, Re: Comments on E. Helena and Anaconda Facilities. May.

[18] Montana Department of Health and Environmental Sciences, 1980. Laboratory Analysis from Slag Pile, and Preliminary Investigation Notes for Slag Pile.

This facility was listed on the Superfund National Priorities List (NPL) in 1983. Areas of the site identified as requiring study included process water ponds, slag piles, and areas with elevated levels of heavy metals in the soils. To facilitate these studies, the site was divided into five "operable units," one of which consists of the slag piles.[19]

Although a documented link has not been established, the slag piles have also been considered by ASARCO as potential sources of ground-water contamination. A ground-water monitoring investigation completed by ASARCO on February 7, 1986 indicated that concentrations of some heavy metals and arsenic in surface and ground-water exceeded drinking water standards. Specific data were not provided. All potential sources of contaminants were identified, and the list included the unfumed slag pile and the fumed slag pile.[20] Elevated levels of arsenic (up to 0.620 mg/L), zinc (up to 3.7 mg/L), and sulfates (up to 11,750 mg/L) were measured in 1987 by ASARCO in water from within the slag piles.[21] Ground-water monitoring data from 1986 discussed in the 1987 Remedial Investigation for this site showed that monitoring wells downgradient of two process wastewater impoundments and the slag pile "have elevated concentrations of sulfate and arsenic."[22] However, site maps showing the locations of the arsenic and sulfate plumes reveal that the contamination has been caused mainly by the wastewater impoundments, not the slag pile.

While two of the three wells downgradient of the slag pile showed elevated levels of arsenic, manganese and sulfate, the upgradient well also showed elevated levels of these contaminants. Exhibit 10-8 provides the results of these analyses. This upgradient well is located in the area influenced by seepage from the wastewater impoundments.

ASARCO, Glover, Missouri

ASARCO's Glover lead smelter is situated in a lead-rich region known as Missouri's "Old Lead Belt," within the Mark Twain National Forest in the Missouri Ozarks. ASARCO began operations at this facility in 1968. Slag generated by the smelter is stored in an on-site pile which is upslope and upgradient of the facility. Wastewater discharges (NPDES), surface run-off, and ground-water flow from the facility are all directed towards or into Big Creek. Although no documentation was found directly stating that the lead slag piles were the source of heavy metals releases to surface or ground waters, some of the data reviewed suggest that the lead slag is at least part of the source.

In May 1985, ASARCO conducted a hydrologic characterization of the Glover facility. Data from this study showed that, in contrast to background or upgradient samples, elevated cadmium, zinc, manganese, and possibly chromium concentrations were present in many surface and ground-water samples collected downgradient of the lead slag pile. (See Exhibit 10-9.) Cadmium concentrations exceeded the MCL by a significant amount in bedrock wells (0.027 - 0.053 mg/L) and shallow wells (0.52 - 2.3 mg/L), as well as surface waters (0.52 - 4.3 mg/L) downgradient of the slag.

Manganese and zinc were also present in the shallow wells and surface water downgradient from the slag pile.[23] Background values for the deep aquifer were not available.

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[19] EPA Region VIII and Montana Department of Health and Environmental Sciences, 1989. Superfund Program Proposed Plan - East Helena Smelter Site.

[20] ASARCO, 1986. Draft Report on Water Resources Monitoring - Asarco East Helena Plant.

[21] ASARCO, 1986. Test Hole Logs performed for Asarco by Hydrometrics and miscellaneous sample results from Asarco tests.

[22] CH^{2}M Hill, 1987. East Helena Smelter (Asarco) Site Profile.

[23] ASARCO, 1990. Letter from G.F. Lubbers, ASARCO Glover, to D. Bussard, EPA Headquarters, Waste Management Division, Re: (None) Response to data request.

Exhibit 10-8
Results from Groundwater Quality Analysis
ASARCO, East Helena, Montana

Sampling Date	Well Name[a]	Parameter (mg/L)					
		Pb	As	Cu	SO_4	Cd	Mn
01/06/85	DH-6[b]	<0.005	8.4[d]	0.013	**545**[e]	<0.001	**0.054**
01/18/85	DH-7[b]	<0.005	0.005	<0.008	74.7	<0.001	0.041
01/18/85	DH-10[b]	<0.005	5.10	0.009	**352**	0.003	**4.80**
06/11/85	Dh-9[c]	0.007	10.4	0.010	**415**	0.006	**0.463**

(a) It appears that most of the private wells in East Helena are drilled at depths ranging from 10 to 49 meters. Thus, it can reasonably be expected that the depth to groundwater for the above wells is similar.

(b) Based on potentiometric surface maps of the site, these sampling points appear to be downgradient of the slag pile.

(c) Based on the same maps mentioned above, it appears that this sampling point is upgradient of the slag pile.

(d) The concentrations which are underlined represent exceedances of the National Primary Drinking Water Regulations.

(e) The concentrations in bold (not underlined) represent exceedances of the National Secondary Drinking Water Regulations.

Exhibit 10-9
Summary of Exceedances from Well and Surface Water Analyses
ASARCO, Glover, Missouri

Station[a]	Total No. Samples[b]	No. Samples Exceeding MCL/Maximum Exceedance Factor[c]						
		Cd	Fe	Mn	Pb	Zn	TDS	SO_4
Deep Aquifer								
Downgradient								
103D	3	2/5.3	0	0	2/1.4	0	3/4.04	3/4.52
Shallow Aquifer								
Upgradient								
101	6	0	0	0	1/1.4	0	0	0
102	6	0	0	0	0	0	0	0
Downgradient								
MW-4	6	6/230	1/2.1	5/2.4	3/2.4	2/1.86	6/4.01	6/4.76
103	3	3/4.5	0	0	0	0	3/1.88	3/1.82
104	6	6/57	6/6.8	6/9.9	1/1.6	0	5/2.29	3/2.41
105	6	0	0	4/2.3	1/1.6	0	0	0
MW-3	6	3/1.7	0	0	3/1.6	0	0	0
Surface Water								
Scroggins Branch								
300	5	0	0	0	0	0	0	0
301	6	1/1.2	0	0	1/1.6	0	0	0
Slag Seep								
303	6	6/430	0	1/1.26	6/5.6	5/7.14	6/2.65	6/3.28

(a) •Bedrock Well = 103D (Depth to gw=12.3m; distance from slag pile<50m).
•Shallow Wells = MW-4 (depth<2m; distance=100m); MW-3 (depth<3m; distance=100m); 104 (depth=1m; distance=100m), and 105 (depth=1.7m; distance<200m); Background (referenced by ASARCO) = 101 (depth=0.76m; distance=244m); and 102 (depth=1.2m; distance=732m).
•Surface Water Station = 303 (Slag Pile Seep); Background - Scroggins Branch (referenced by ASARCO) = 300 (distance from slag pile=244m) and 301 (distance=152m).

(b) •Samples collected between 8/84 and 3/86.

(c) •First value is number of samples exceeding MCL. Second value is Maximum Exceedance Factor, derived by dividing highest concentration detected by the MCL (e.g., a concentration of 0.12 mg/L lead exceeds the MCL of 0.05 mg/L by a factor of 2.4).

In October 1985, the Missouri Department of Natural Resources (MODNR) stated, based on the data reviewed up to that time, that "[e]ither there is a very significant nonpoint source of cadmium or there are significant unreported discharges from ASARCO or there are both."[24]

In May 1987, EPA conducted a Potential Hazardous Waste Site investigation, and expressed concern that "surface water run-off from slag piles could be contaminating the streams surrounding the lead smelter with heavy metals."[25] In 1988, under a Settlement Agreement with the MODNR, ASARCO constructed a collection and treatment system for stormwater run-off from the facility, including the slag area.

Doe Run, Boss, Missouri

Doe Run's Buick primary smelter facility, like ASARCO's Glover facility, is situated within Missouri's "Old Lead Belt." The facility, which began operating in 1968, was originally owned by the Amax Lead Company and is also known as the AMAX Homestake Smelter. The 101 hectare (250-acre) plant is located near the towns of Boss and Bixby, Missouri, in Iron County.

The site is located on a ridge separating the watersheds of the Left Fork of Neals Creek (to the south) from that of Crooked Creek (to the north.) This area has been identified as a recharge area for the underlying aquifer. There are private drinking water wells within a 1.6 km radius of the facility. The water table occurs at 44.2 m (145 feet) below the land surface in both the wet and dry seasons. A perched water table also exists at five feet below the land surface. Crooked Creek receives wastewater discharges from smelting operations, while Strother Creek receives discharges from the mine and mill. The mean annual precipitation is about 1.2 meters (46 inches).[26]

The slag disposal area consists of a flat-topped "bench" along the eastern side of the head of a small valley that is underlain by clay-based residuum. The slag is piped as a slurry to the slag disposal area where it is dewatered, then trucked to the on-site sinter plant for reuse as sinter, or disposed in the slag disposal area.[27] A total of about 480,000 tons of slag have been placed in the slag disposal area over nearly 20 years of primary smelter operation. The piled slag covers about 20,000 square meters (5 acres) at its base with a thickness of 6.1 to 16.8 meters (20 to 55 feet).[28] The slag pile is generally unvegetated.

In 1984 EPA Region VII performed a Potential Hazardous Waste Site Preliminary Assessment. The inspector found that "surface impoundments and slag piles containing heavy metals could possibly contaminate ground and surface water." The inspector also listed blowing dust from the slag pile under "Hazardous Conditions and Incidents."[29]

Doe Run began a comprehensive investigation of the primary smelter slag disposal area in 1984. Soil boring analyses revealed that some residuum samples from beneath the slag contained elevated concentrations of lead, zinc, and cadmium. Exhibit 10-10 shows analyses of boring samples typical for uncontaminated residuum, contaminated residuum, and the slag itself. These data show that uncontaminated residuum might contain up to 10 mg/kg lead. The slag itself may contain 3,800 mg/kg, while the residuum contaminated from slag leachate may contain 2,400 mg/kg lead. Similar comparisons can be made for zinc and cadmium, and possibly copper.[30]

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[24] Missouri Department of Natural Resources, 1985. Memo from J. Ford to R. Hentges, Re: Discharges from the ASARCO smelter at Glover.

[25] U.S. EPA Region VII, 1987. Potential Hazardous Waste Site, Site Identification, for ASARCO lead smelter in Glover, Missouri.

[26] Doe Run Company, 1989. Buick Resource Recovery Facility RCRA Part B Permit Application.

[27] Ibid.

[28] Barr Engineering, 1989. Letter from D. Connell to D. Kennedy, Region VII, Re: Revised RCRA Facility Assessment Report (Copy of Report Attached).

[29] U.S. EPA Region VII, 1984. Potential Hazardous Waste Site, Preliminary Assessment, for Amax Lead Co. smelter in Boss, Missouri.

[30] Doe Run Company, 1989. Buick Resource Recovery Facility RCRA Part B Permit Application.

Exhibit 10-10
Metals Content of Slag and Residuum
Doe Run, Boss, Missouri

Sample	Description	Depth (ft)	Concentration (mg/kg)			
			Pb	Zn	Cd	Cu
K1	Residuum	16 - 16.5	5.4	16	0.11	37
K2	Residuum	54 - 54.5	10	27	0.13	41
K9	Residuum	43.5 - 44	2,400	390	7.3	160
K10	Residuum	21 - 22	990	230	2.8	28
K9	Slag Pile	24 - 24.5	3,800	6,800	14	250

Monitoring well data from 1988 show that cadmium, lead, and zinc concentrations in the ground water below the slag disposal area exceed drinking water standards. These data, summarized in Exhibit 10-11, show that contamination of the ground water below the slag disposal area has occurred, though it is unclear if this contamination can be attributed to the slag pile directly or to two adjacent impoundments that contain water from the slag storage area. Several independent laboratories analyzed subsamples of each sample to derive a mean value. Mean cadmium levels ranged up to 0.67 mg/L (67 times the MCL); lead ranged up to 0.6 mg/L (12 times the MCL); and one mean value for zinc contained 7.4 mg/L (1.5 times the MCL). Three wells had consistently elevated cadmium levels: the 11 samples from well K2 averaged 0.087 mg/L; the six samples from well K5A averaged 0.431 mg/L; and the six samples from well K8 averaged 0.021 mg/L. These wells were all located within 125m of the slag disposal area, and all appeared to be downgradient.[31] Background monitoring well data were not located in the available documentation.

Midvale Slag, Midvale, Utah

Slags from both primary copper and lead smelting operations have been co-disposed at this facility. Heavy-metal contamination of ground-water has been linked to these slag deposits. This situation is more fully described under Damage Case Study Findings for the copper sector (Section 6.3.2).

ASARCO, El Paso, Texas

This facility contains combined deposits of lead, copper, and zinc slag. Heavy metal contamination of water and sediments in the Rio Grande River have been linked to these slag deposits. This situation is more fully described under Damage Case Study Findings for the copper sector (Section 6.3.2).

10.3.3 Findings Concerning the Hazards of Lead Slag

Review of available data on the slag and slag leachate constituent concentrations indicates that 12 constituents are present in concentrations that exceed the risk screening criteria used in this analysis by more than a factor of 10: arsenic, cadmium, chromium, lead, selenium, antimony, silver, zinc, iron, cobalt, manganese, and mercury. Of these constituents, arsenic, cadmium, lead, mercury, and selenium in lead slag leachate were also measured using the EP leach test in concentrations that exceed EP regulatory levels. Concentrations measured using the SPLP leachate test, however, never exceeded the EP regulatory level.

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[31] Ibid.

Exhibit 10-11
Summary Monitoring Well Data for the Slag Disposal Area(a)
Doe Run, Boss, Missouri

Well No.	Depth to g.w. (ft)	Date	Averaged Results from 3 to 4 Labs (mg/L)			
			Cd (0.01)(b)	Pb (0.05)(b)	Zn (5.00)(c)	Mn (0.5)(c)
K2	42.4	06/09/88	0.08	–	–	2.0
K2	42.4	07/07/88	0.07	0.09	–	2.5
K2	42.4	08/10/88	0.09	0.60	–	2.7
K2	42.4	09/15/88	0.12	–	–	4.1
K2	42.4	10/13/88	0.082	–	–	3.0
K5a	24.0	06/09/88	0.48	–	–	0.84
K5a	24.0	09/15/88	0.67	–	7.4	1.7
K6	10.9	08/10/88	–	0.08	–	–
K8	81.0	06/09/88	0.21	0.08	–	1.8
K8	81.0	09/15/88	0.022	–	–	2.9
K10	138.1	07/07/88	–	–	–	2.3
K10	138.1	08/10/88	–	0.08	–	0.66
K12	95.1	08/10/88	–	0.06	–	–
K13	136.3	06/09/88	–	0.118	–	1.2
K13	136.3	07/07/88	–	0.077	–	1.7
K13	136.3	08/10/88	–	0.08	–	1.6
K13	136.3	09/15/88	–	–	–	1.9

(a) By noting positions on potentiometric map, wells were all downgradient, and within 125m of slag disposal area.
(b) Primary MCL (mg/L)
(c) Secondary MCL (mg/L)

Based on an examination of the characteristics of each site and predictive modeling, the most likely pathway for contaminants to be released into the environment is through erosion to surface water. At the Glover, East Helena, and Boss facilities, the Agency estimated that, without any run-off controls, erosion from lead slag piles may result in annual average concentrations of arsenic, lead, iron, manganese, and/or zinc in nearby creeks that exceed human health and ecological protection criteria, by as much as a factor of 19. However, run-off from the slag piles at the Glover and Boss facilities is presently collected and treated prior to discharge. Depending on the efficiency of these control systems, surface water contamination caused by slag pile run-off at Glover and Boss is likely to be significantly lower than predicted.

Significant releases to ground water appear less likely considering the generally low net recharge, low permeability of the earth materials underlying the slag piles, and large depths to useable ground water at each facility, as well as the tendency of most of the metals in lead slag to bind to soil. At three facilities, the Agency predicts that the metals from lead slag piles would be largely bound to subsurface soil and would not reach ground water within 200 years. However, the Agency's modeling indicates that, under natural recharge conditions, ground water within the facility boundary at Glover and East Helena could be contaminated with cobalt in excess of irrigation guidelines. Also at Glover, the Agency predicts that arsenic concentrations in ground water could cause a cancer risk of $4x10^{-7}$, but this contamination is expected to be confined to the facility property and is well below the MCL.

Air pathway modeling indicates that it is very unlikely for slag piles to cause harmful concentrations of contaminants in the air at the nearest residences.

Monitoring data collected during the Agency's efforts to identify documented cases of damage confirm the existence of high contaminant concentrations in leachate seeps and/or run-off from lead slag piles. In particular, monitoring data show that "surface water seeps" from slag piles at the Glover and East Helena facilities contain arsenic, lead, and/or cadmium in concentrations that exceed the primary drinking water standards. These seeps appear to represent largely undiluted leachate and run-off, rather than ambient surface water concentrations after contaminants have been fully mixed in the flow of nearby creeks, as analyzed by the modeling. However, the documented presence of the seeps and their high contaminant concentrations generally support the modeling conclusion that run-off, if not controlled, could be an important contributor to surface water contamination. As noted above, the Glover facility now collects and treats fluids coming from the pile prior to discharge. In addition, the East Helena facility has discontinued the practice of sprinkling the pile with wastewater to control dust, which was believed to be the primary source of the slag pile seepage.

Information collected during the damage case research also suggests that the slag pile at the Boss facility may be a source of surface water contamination. Site-specific modeling at this facility predicts that run-off from the slag pile, if not controlled, could result in iron and manganese concentrations in Crooked Creek that exceed the MCLs by a factor of 2, and lead concentrations that exceed the proposed revised MCL for lead by a factor of 12. This creek, however, is not currently used as a source of drinking water within 24 km of the facility, and given its low flow (16 mgd), it is uncertain if it could provide a drinking water supply in the future. Furthermore, the slag pile is equipped with stormwater run-off controls, and the actual contaminant concentrations in Crooked Creek are likely to be lower than predicted.

Monitoring data collected for the damage cases suggest more ground-water contamination than is predicted by the modeling. Monitoring data for the Glover, East Helena, and Boss facilities indicate that primary drinking water standards for lead, cadmium, and arsenic have been exceeded in ground water on the plant property. At all three sites, lead slag is only one of several possible sources of the observed contamination, though the slag pile appears to be the primary source of contamination of some of the wells at the Glover facility. The Agency's modeling predicts that the slag piles at Glover and East Helena may cause ground water contamination, but not at the levels and downgradient distances that were observed. Similarly, the Agency predicted essentially no ground-water contamination at Boss. These differences appear to be caused by the following factors:

- It appears likely that the contamination observed in a well approximately 100 meters downgradient from the slag pile at Glover was caused, in part, by overland migration of fluids from the pile. As described previously, highly concentrated "surface seeps" near the base of the pile have been observed at this site. Prior to the installation of run-off controls in 1988, it may have been possible for this seepage to migrate over the land or through drainage ditches and then percolate into this shallow well (which is screened at a depth of only 2 meters).

- The slag pile at the East Helena facility is downgradient from two process wastewater ponds that appear to be the principal contributors to ground-water contamination. The documented presence of contamination upgradient of the slag pile substantiates that other release sources are likely to exist. Furthermore, it is possible that some, if not most, of the ground-water contamination potentially attributable to the slag pile was caused by the former practice of sprinkling contaminated wastewater on the pile for the purpose of dust control. This water added to the pile provided a much larger contaminant load and created a much greater potential for leaching than the naturally low precipitation and recharge considered in the modeling.

- The slag pile at the Boss facility is adjacent to two unlined impoundments that may be contributing to the observed contamination. In addition, the facility is underlain by dolomite, which is prone to form solution cavities that can allow contaminants to migrate readily in ground water. It is possible that some of the observed ground-water contamination at this site migrated through such cavities, which were not considered in the modeling.

10.4 Existing Federal and State Waste Management Controls

10.4.1 Federal Regulations

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations" which provide the basis for the minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT effluent limitations allow no discharge from hard-lead refining slag granulation. These limitations do not apply to stormwater point sources, such as run-off from a slag pile, or to mining and beneficiation operations. Other processes related to slag management for which discharges are allowed include:

Dross reverberatory slag granulation (40 CFR 421.72(d)):

Pollutant	Daily Maximum	Average Maximum Monthly
Total Suspended Solids	236,000 mg/kkg	112,300 mg/kkg
Lead	9,499 mg/kkg	4,318 mg/kkg
Zinc	8,405 mg/kkg	3,512 mg/kkg
pH	7.5 - 10	

Blast furnace slag granulation (40 CFR 421.72(c)):

Pollutant	Daily Maximum	Average Maximum Monthly
Total Suspended Solids	153,000 mg/kkg	72,400 mg/kkg
Lead	6,155 mg/kkg	2,798 mg/kkg
Zinc	5,446 mg/kkg	2,276 mg/kkg
pH	7.5 - 10	

BAT limits for existing sources for processes related to slag management include:

Dross reverberatory slag granulation (40 CFR 421.73(d)):

Pollutant	Daily Maximum	Average Maximum Monthly
Lead	1,612 mg/kkg	784.4 mg/kkg
Zinc	5,872 mg/kkg	2,418 mg/kkg

No discharges are allowed under BAT from blast furnace slag granulation or hard lead refining slag granulation. No discharges of slag waters are allowed from new sources (40 CFR 421.73(c), 421.74(c) and (d)).

EPA has, under the Clean Air Act (40 CFR 60.180), established the national primary and secondary ambient air quality standards (NESHAP) for lead at 1.5 μg/dscm.

10.4.2 State Regulation

The five primary lead processing facilities that generate lead slag are located in Missouri (three facilities), Montana (one facility), and Nebraska (one facility). Only Missouri and Montana were selected for detailed regulatory review for the purposes of this report (see Chapter 2 for a discussion of the methodology used to select states for detailed regulatory study).

All three states with facilities generating lead slag exclude mineral processing wastes from their hazardous waste regulations. Historically, Missouri also has not addressed lead slag under its solid waste regulations. Montana classifies lead slag as solid waste, but exempts solid wastes managed on-site, such as the slag generated at the East Helena facility, from regulatory requirements. Although not studied in detail, a brief review of Nebraska's regulations suggests that this state does not address lead slag as a solid waste. Missouri does currently require owners/operators of lead facilities to obtain NPDES permits for storm water discharges, and thus establish run-on/run-off controls. According to state officials in Montana, run-off from lead slag piles does not require a NPDES permit and is not addressed otherwise. Finally, although mineral processing facilities in both states must obtain air permits in order to operate, there are no specific regulations addressing fugitive dust suppression for lead slag in either state.

In contrast to this current lack of formal control, Missouri recently passed a Metallic Minerals Waste Management Act, which will apply to generators of lead slag. This act requires that facility owners/operators submit permit applications for active existing and new operations. Each permit application must include operating information, a detailed closure plan, an inspection and maintenance plan, and provisions for financial assurance. Nonetheless, because the state has not yet promulgated regulations to implement the Act, and the first permitting cycle has not yet been completed, the extent and nature of environmental controls that will ultimately be imposed on the slag management activities of the state's three facilities cannot be predicted.

In summary, neither of the two study states with primary lead processing facilities have imposed environmental controls, under either hazardous or solid waste regulatory authorities, on the lead slag management activities conducted at those facilities in the past. Moreover, although Missouri recently enacted new minerals waste legislation and appears to be preparing to actively address lead slag, the state has not yet promulgated regulations to implement that legislation. The nature and extent of environmental control requirements ultimately placed on lead slag wastes, therefore, cannot be predicted with confidence at this time.

10.5 Waste Management Alternatives and Potential Utilization

10.5.1 Waste Management Alternatives

Waste management alternatives, as discussed here, include both waste disposal (e.g., in landfills and waste piles) alternatives and methods of minimizing the amount of waste generated. Waste minimization alternatives include any source reduction or recycling that results in either the reduction of total volume or toxicity of the waste. Source reduction is a reduction of waste generation at the source, usually within a process. Source reduction can include: process modifications, feedstock (raw material) substitution, housekeeping and management practices, and increases in efficiency of machinery and equipment. Source reduction includes any activity that reduces the amount of waste that exits a process. Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process.

Opportunities for waste minimization through raw materials substitutions are limited in general by the characteristics of the ores that are processed. Selection of source ores and improved beneficiation techniques, however, may lead to reduced slag volumes in some cases . Other source reduction opportunities may involve process modifications that increase the efficiency of metal recovery during the smelting operation.

Recycling blast furnace slag to the sinter plant, and recovering lead and zinc from the slag by slag fuming, are the primary waste minimization practices currently employed in the primary lead processing sector.

Recycling Lead Slag

Description

The purpose of recycling blast furnace slag to the sinter plant is to recover metals that would otherwise remain in the slag, and to control the concentration of lead in the materials being fed to the sinter plant. When recycled, the slag is blended with the other sinter plant input materials (e.g., ore concentrates, flue dust, and fluxes). The resulting mixture is pelletized and roasted in the sinter plant. At facilities which practice slag recycling, approximately 36 percent of the sinter plant's feed is made up of slag.[32]

Current and Potential Use

Of the five primary lead processing facilities in the U.S., the three facilities in Missouri recycle as much as 73 percent of their slag to the sinter plant.[33] The galena ore in Missouri is rich in lead content, so that the facilities there may need to recycle their slag to the sinter plant, even if it means retrieving slag from the waste pile.[34]

The ASARCO facilities in East Helena, Montana and Omaha, Nebraska do not recycle their lead slag.[35] Presumably the East Helena facility does not recycle its slag because the lead concentrations of the ore concentrate they process are lower than in the Missouri ore concentrate (74-76 weight percent).[36] ASARCO's facility in Omaha, Nebraska does not have the option of recycling its slag on-site since it only refines lead bullion and does not have a sinter plant or blast furnace. Apparently it is not economically feasible to transport the slag to another facility for recycling.

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[32] PEDCo Environmental, Inc., 1980. Industrial Process Profiles for Environmental Use. Chapter 27: Primary Lead Industry, EPA-600/2-80-168, Environmental Protection Technology Series, Industrial Environmental Research Laboratory, ORD, U.S. Environmental Protection Agency, July, p. 25.

[33] Doe Run, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

[34] Ibid.

[35] EPA in house information, July 1987.

[36] PEDCo Environmental, Inc., op. cit. pp. 17-18.

Therefore, of the two facilities that do not recycle their slag, only East Helena has the alternative available, and it is uncertain what impact recycling would have on the volume or composition of slag being generated. The amount of slag being recycled at the three Missouri facilities could perhaps be increased by implementing process modifications, but it is uncertain whether this would significantly reduce the quantity of slag ultimately disposed.

Factors Relevant to Regulatory Status

While the specific effects of slag recycling on slag volume and composition are uncertain, data on the composition of slag from different ores and refining processes[37,38,39] suggest that recycling will not reduce waste volume or lead content by more than a few percent. Therefore, the use of recycling is unlikely to change the way in which lead slag should be regulated.

Feasibility

The recycling of slag at ASARCO's East Helena facility is almost certainly technically feasible, as is the possibility of increasing the amount of slag being recycled at the three Missouri facilities, but it is not certain that more recycling would be profitable. The primary factor influencing a facility's decision to recycle smelter slag is the concentration of metal in the slag. Slags with low lead content are likely to be disposed of instead of recycled due to the increased costs associated with recycling and the minimal benefits (e.g., small quantities of lead recovered).

Slag Fuming

Description

The primary purpose of slag fuming is to recover zinc oxides, created through reoxidation of the metals in the bottom portion of the blast furnace, which would otherwise remain in the slag. Lead recovery by slag fuming is also possible to some extent. Slag fuming is done by charging the molten lead slag to a fume furnace and injecting a stream of air and pulverized coal to maintain the necessary temperature and a reducing environment. The zinc and lead are then reoxidized by a stream of secondary air above the surface of the slag, and collected as particulate matter from the furnace gases.[40]

The waste streams from slag fuming consist of the exhaust gas, which contains the zinc and lead being recovered and the volatile components of the blast furnace slag,[41] the remaining slag, and water used to quench and granulate the slag. The exhaust gas is controlled/treated by first cooling it and then sending it to baghouses where the particles are removed and the volatile components are condensed. The remaining slag is believed to be physically and chemically similar to unfumed slag, being made up of compounds of aluminum, calcium, iron, magnesium, silicon, and other elements.[42] (The main difference between fumed and unfumed slag is the reduced concentrations of lead, zinc, and volatile components in the fumed slag.) The fumed slag

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[37] Ibid., p. 37.

[38] Higgins, Leo M. III, William H. Bauer, and Dodd S. Carr, 1980. "Utilization of Lead and Zinc Slags in Ceramic Construction Products," Conservation & Recycling, Vol. 3, p. 376.

[39] Collins, R.J. and R.H. Miller, 1976. Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis, FHWA-RD-76-106, prepared for Federal Highway Administration, May, p. 119.

[40] PEDCo Environmental, Inc., op. cit. p. 42.

[41] Ibid.

[42] Ibid.

is disposed of by cooling it with either air or water (which granulates it), and sending the cooled slag to a waste pile or tailings pond. When water is used to quench the fumed slag, the concentrations of sulfate have been observed to increase by 70 ppm, lead by 0.18 ppm, and zinc by 0.38 ppm,[43] which are comparable to the changes seen in unfumed slag quench water. Water used to quench and granulate the slag may undergo some form of treatment before being reused or discharged, but the portion used to slurry the granulated slag if often disposed with the slag.

Current and Potential Use

Of the four active U.S. facilities with smelting operations, none are currently using slag fuming to recover zinc oxide or lead from their blast furnace slag. At present, only the ASARCO facility in East Helena, Montana is believed to have slag fuming equipment installed, but it has not fumed slag since the early 1980's. The three facilities in Missouri also used to run slag fuming operations but no longer do so, and have removed their fuming ovens. EPA believes that the reason these facilities no longer have active fuming operations is that electric arc furnace dust from steel production and zinc slab are sources of purer, less expensive zinc oxide. If the price of zinc oxide were to rise, it is possible that ASARCO's East Helena facility would resume slag fuming. The lead facilities in Missouri might also resume slag fuming, but they would require more incentive than the East Helena facility, because they would have to install fuming equipment.

Factors Relevant to Regulatory Status

Lead and zinc concentrations in lead slag can range from 0.1 to 3.5 and from 2.0 to 17.5 percent by weight, respectively.[44,45] Therefore, even with complete lead and zinc recovery, slag fuming could reduce the amount of slag generated by a maximum of 21 percent by weight, and perhaps by as little as 2.1 percent by weight. Assuming an annual slag production of 540,000 metric tons,[46,47] that all of the slag is fumed, and that all of the lead and zinc are recovered from the slag, the amount of slag would be reduced by 11,340-113,400 metric tons per year.

EPA does not believe that the use of slag fuming is likely to result in the need for regulations more stringent than would be applied to unfumed slag. In fact, fumed slag could potentially be of less concern than unfumed slag due to the lower toxic metal content.

Feasibility

While slag fuming may not be technically feasible at the ASARCO facility in Omaha, Nebraska, slag fuming has seen extensive use in the past at the facilities in Montana and Missouri. Therefore, its technical feasibility has been demonstrated. Economic feasibility hinges on the price of the zinc oxide produced and/or the benefits that might be derived from lowering the slag's lead and zinc concentrations.

Disposal Alternatives

Of the five lead processors, only the facility in Omaha, Nebraska sends its slag off-site for disposal. While it is conceivable that some, or even all, of the other lead processors could do so, the cost of transporting large volumes of lead slag, and the rising cost of commercial landfill capacity make it unlikely that lead processors will utilize off-site disposal capacity if on-site capacity is available and the regulations do not change.

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[43] Ibid., p. 43.

[44] Ibid., p. 37.

[45] Collins, R.J. and R.H. Miller, op. cit. p. 119.

[46] This figure is based on the four smelting facilities operating at their maximum capacity and generating one ton of slag for every ton of lead.

[47] PEDCo Environmental, Inc., 1980, op. cit. p. 6.

10.5.2 Utilization

Utilization as a Construction Aggregate in Asphalt

Description

Lead slag has been used as an aggregate in asphalt used to surface roads. If the slag is water cooled (i.e., granulated) it may be usable with little or no crushing and screening. If, however, the slag is air-cooled, it will almost certainly require processing to produce the desired particle sizes. Once the slag has been sized it can then be mixed with the asphalt mixture.

Current and Potential Use

Lead slag was field tested as an aggregate in asphalt paving during the mid 1970s.[48] Lead slag has been shown to have desirable anti-skid and wear resistant properties,[49] and was used as an asphalt aggregate in eastern Missouri for a number of years in the 1970s. The Missouri State Highway Commission also made limited use of lead slag in asphalt mixtures used to patch and seal roads in the winter. In Idaho, the asphalt used to pave Interstate Route 90 utilized granulated lead slag as an aggregate.[50] EPA, however, has found no information indicating that lead slag is currently being used as an aggregate in asphalt road paving.

The potential of lead slag as a construction aggregate depends at least partly on its ability to compete successfully in the market place with the other sources of aggregates. Two of these factors are discussed below, and a third (competitive pricing) is discussed in the section on Feasibility.

Access to Markets

It is important that the waste be located as close as possible to its market in order to keep transportation costs low. Waste located within 80 and 160 km (50 to 100) miles of major metropolitan areas or aggregate shortage areas are considered as being near potential markets.[51] The three facilities in Missouri are all located within 160 km (100 miles) of both St. Louis and Springfield. The facility in East Helena, Montana is located within 160 km (100 miles) of Butte and Helena, and within 320 km (200 miles) of an area in central Montana with an aggregate shortage. The ASARCO plant in Omaha, Nebraska is located within the metropolitan area of Omaha, and is within 160 km (100 miles) of southwestern Iowa, which has a shortage of aggregate. Therefore, all of the facilities have potential markets for use of their slag as an aggregate material.

Factors Relevant to Regulatory Status

The use of lead slag in asphalt is unlikely to alter the chemical composition of the slag. EPA believes that the physical entrainment of the slag in the asphalt will reduce the leaching of hazardous constituents from the slag as compared to disposal in an uncovered waste pile. However, to the extent that hazardous constituents do leach from slag used as aggregate in asphalt, the releases would be less controllable than those from a more localized source such as a waste pile.

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[48] Collins, R.J. and R.H. Miller, op. cit. pp. 200 and 210.

[49] Ibid., p. 167.

[50] Ibid., p. 166.

[51] Collins, R.J. and R.H. Miller, op. cit. p. 239.

Any slag particles that are too small to be used as an aggregate will still have to be disposed, unless they can be utilized in some other way (e.g., as a substitute for portland cement, as is discussed later). If disposed, there will be a greater potential for leaching or transport as dust due to the relatively small particle size.

Feasibility

The perception that lead slag might be harmful has entirely stopped its utilization as a component of asphalt for road paving. The use of granulated lead slag as an aggregate in asphalt in eastern Missouri was discontinued in the mid-1970s because the Missouri Department of Natural Resources suspected that there were significant amounts of lead in the slag, and that lead might escape into the environment through leaching. The Missouri lead producers, in order to avoid negative publicity, withdrew their slag from the market and chose instead to dispose of it as they had in the past.[52]

In the event that the relevant agencies of State government were to reverse their position on this issue, the economic viability of lead slag as an aggregate would depend on the selling price of the slag, the cost of retrieving the slag from the disposal area, the amount of crushing and screening needed to size the slag, and the distance the slag would have to be transported prior to use.

10.5.3 Miscellaneous Utilization

There are a number of ways to utilize lead slag which are mentioned in the literature, but for which there is little information beyond the fact that a particular practice may have occurred. Below, EPA discusses and comments on each potential means of waste utilization to the extent permitted by the information available.

Substitute for Portland Cement in Construction Blocks

It has been shown that finely ground lead slag can be used to replace up to 25 percent of the portland cement in steam cured blocks without a significant loss in block strength.[53] The blocks are manufactured from a mixture of sand, portland cement, ground slag, and water, which is pressed into shape and then steam cured for 10 hours at 90 degrees centigrade. Whether the slag in such blocks would pose any risk to human health or the environment is not known; moreover, it is unclear whether the economics of utilization would be favorable, since the slag would require extensive grinding before use.

Frost Barrier and Buried Pipeline Bedding Material

In Idaho, granulated slag from the Bunker Hill Company smelter in Kellogg, Idaho (now closed), was used as a frost barrier under slabs of concrete and asphalt, as well as a bedding material for buried pipelines.[54] The literature does not report how much lead slag has been used for these purposes, or how it performed.

Using lead slag as a pipeline bedding or frost barrier material will not change the chemical or physical characteristics of the slag, although it may have some effect on the ability of the slag's hazardous constituents (e.g., lead and cadmium) to leach and contaminate ground and/or surface waters. For instance, when the slag is used as a frost barrier under cement or asphalt slabs, the amount and rate of leaching should be reduced significantly with respect to current slag waste management practices that allow water to run over the slag.

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[52] Ibid., p. 167.

[53] Higgins, Leo M. III, William H. Bauer, and Dodd S. Carr, op. cit. pp. 375-382.

[54] Collins, R.J. and R.H. Miller, op. cit., p. 166.

When slag is used as bedding material for pipelines, the rate of leaching will depend on environmental settings, and could vary considerably.

Air-Blasting Abrasive

Lead slag has been used as an air-blasting abrasive. Slag from a closed smelter site (currently owned by the Valley Materials Corporation) in Midvale, Utah is being processed and sold as air-blasting abrasive by Blackhawk Slag Products in Utah, Colorado, and Nevada. The slag is processed into four different size grades and sold for such uses as the removal of paint from concrete and steel structures, as well as the removal of road paint stripes.[55]

It is not known how much lead slag is currently being sold as air-blasting abrasive, or the scope of the potential market for this product. No information has been found to indicate that lead slag at other sites in the United States could not be utilized as air-blasting grit.

Virtually all of the slag that is used as input in the production of the abrasive is incorporated in the product, so disposal of the residues poses no problem. The primary concerns with respect to human health and the environment arise from the potential for inhaling the grit when it is used, and the leaching of heavy metals from the grit after it has been used. Blackhawk does not believe that the potential dangers from inhalation of the grit pose a significant threat to human health if people without protective equipment are kept away when it is being used.[56] It is not known how much of the grit might be picked up by the wind and inhaled by people. With respect to leaching, results from EP toxicity test extract analyses of the air-blasting grit were all well below the regulatory standards.[57]

Railroad Ballast

Valley Materials Corporation in Midvale, Utah also is processing (sizing) slag for use as a railroad ballast. It is not known how much lead slag is currently being sold for use as railroad ballast, or the scope of the potential market for this product. No information has been found to indicate that lead slag at other sites in the United States could not be utilized in this way.

The slag at the Midvale site has been tested for EP Toxicity and found to be well below the regulatory standards.[58]

10.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if land disposal restriction had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D-Plus program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

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[55] Earthfax Engineering, Inc., 1986. Leaching Potential of Slag and Slag-Based Air-Blasting Abrasives, June.

[56] Private communication with Mr. Bob Soehnlen, Vice President, Blackhawk Slag Products, Midvale, Utah, April 18, 1990.

[57] Earthfax Engineering, Inc., op. cit.

[58] Ibid.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted-average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S. Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed by primary lead producers under different regulatory scenarios. Next, the Agency discussed the cost implications of requiring these changes to existing waste management practices. The last part of this section predicts and discusses the ultimate impacts of the increased waste management costs faced by the affected lead facilities.

10.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented earlier in this chapter, EPA believes that lead slag poses a relatively high risk, and is likely to exhibit the hazardous waste characteristic of EP toxicity. Accordingly, the Agency has estimated the costs associated with regulating lead slag under RCRA Subtitle C, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus," as previously introduced in Chapter 2, and as described in specific detail below.

In the absence of actual facility-specific sampling and analysis data demonstrating otherwise, EPA has adopted a conservative approach in conducting its cost analysis, and has assumed that lead slag would exhibit EP toxicity at all five lead producing facilities.

Subtitle C

Under Subtitle C standards, generators of hazardous waste that is managed on-site must meet the standards codified at 40 CFR Parts 264 and 265 for hazardous waste treatment, storage, and disposal facilities. Because lead slag is a solid, non-combustible material, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed of in waste piles, EPA has assumed in this analysis that the ultimate disposition of lead slag would be in Subtitle C landfills. Because, however, current practice at all five primary lead facilities is storage and/or disposal of slag in waste piles, the Agency has assumed that the facilities would also construct a temporary storage waste pile (with capacity of one week's waste generation) that would enable the operators to send the lead slag to either on-site or off-site disposal efficiently. Given the relatively large quantities of material generated at four of the five plants (all smelters), EPA has assumed that each of these four plants would, as applicable, continue to recycle the same quantity of slag as it does currently, and would dispose of the remainder in a landfill. To accommodate the portion disposed, EPA believes that, because of cost considerations, each facility operator would construct one on-site landfill that meets the minimum technology standards specified at 40 CFR 264, rather than ship the material off-site to a commercial hazardous waste landfill or build multiple landfills. The fifth facility (ASARCO-Omaha) currently ships its slag off-site for disposal; EPA assumes that this plant has disposal capacity restraints and is, therefore, likely to continue this practice. The facility would, however, have to send the slag to a commercial Subtitle C hazardous waste landfill rather than a commercial or municipal solid waste landfill (at a significant increase in waste management complexity and cost) under this scenario.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-Minus is the facility-specific application of requirements based on potential risk from the hazardous special waste. Under the C-Minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating groundwater resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) would be necessary to protect human health and the environment. Two facilities, those at Herculaneum and Omaha, were determined to have a low potential to contaminate groundwater resources; two others, those at Boss and East Helena, were determined to have a moderate groundwater contamination potential; the fifth, at Glover, was determined to have high potential for groundwater contamination.

Under Subtitle C-minus, potentially hazardous slags can be managed in disposal wastepiles only under low groundwater risk conditions. Therefore, under Subtitle C-minus, both facilities with low groundwater contamination risk would be allowed to continue to operate their present wastepiles (i.e, a disposal wastepile at Herculaneum and storage wastepiles at Omaha), after retrofitting the units with run-on/run-off and wind dispersal/dust suppression controls. The remaining three facilities cannot continue to operate their disposal wastepiles and would be required to build disposal landfills. The units are assumed to require at least a three foot liner of clay protected by a fill layer; in the case of the Glover facility with its high potential for groundwater contamination, a composite liner (i.e., clay with a synthetic liner and a protective fill layer) and leachate collection system are assumed to be required. All four facilities that dispose on-site (i.e., excluding the Omaha refinery) are required to perform groundwater monitoring. In addition, the disposal units must undergo formal closure, including a cap of crushed stone or topsoil and grass, and post-closure care must be performed (e.g., leachate collection and treatment, cap and run-on/run-off control maintenance, and continued groundwater monitoring) for a period of 30 years.

Subtitle D-Plus

As under both Subtitle C scenarios, facility operators would, under the Subtitle D-Plus scenario, be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to groundwater increases. Under this scenario, unlike the Subtitle C-Minus scenario, all facilities, regardless of their risk potential for groundwater contamination, are assumed to be allowed to continue to operate disposal wastepiles. Disposal wastepiles under high and moderate groundwater contamination risk potentials must, however, be adequately lined (e.g., in situ clay is not considered adequate). As none of the three lead facilities determined to have high or moderate risk potential currently conform to this requirement, all three would rebuild disposal units, operating either disposal landfills or wastepiles, depending on the relative cost. The least cost alternative at the East Helena facility is expected to be the disposal landfill, while the disposal wastepile is the least cost alternative at the Glover and Boss facilities. The disposal landfills are assumed to require a clay liner with a protective fill layer under the moderate potential for risk found at East Helena; the new disposal wastepiles employed at Glover and Boss are assumed to be underlain by concrete. Groundwater monitoring is required at all three facilities in addition to run-on/run-off and wind dispersal/dust suppression controls; these practices must be continued through the post-closure care period.

At the Herculaneum and Omaha facilities, current slag management units are acceptable because the potential for ground-water contamination is low. The wastepiles would, however, be retrofitted with run-on/run-off and wind dispersal/dust suppression controls which, as under the Subtitle C-Minus scenario, would have to be maintained through closure and the post-closure care period. Ground-water monitoring and capping at closure is assumed to not be required for management units under Subtitle D-Plus when the ground-water contamination potential is low, though wind dispersal/dust suppression controls must be maintained.

10.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the primary lead sector are presented by facility and regulatory scenario in Exhibit 10-12; all five facilities are assumed to incur costs under the three regulatory scenarios. Under the Subtitle C scenario, annualized incremental regulatory compliance costs range across facilities from just over $1.3 million to just over $5.4 million greater than baseline; the sector-wide total is $14.6 million over baseline. For all of the five facilities in the sector, Subtitle C compliance would imply a significant increase in slag management costs; costs at ASARCO's stand-alone lead refinery at Omaha (which ships its slag off-site for disposal) would increase by a factor of almost five, while on-site disposal costs at the four plants operating lead smelters would increase by at least 25-fold and by as much as 37-fold. Compliance-related capital expenditures are substantial at the four primary lead facilities that conduct smelting operations. New capital expenditures at the Boss facility would exceed $3.2 million, while new waste management units at the Glover, Herculaneum, and East Helena facilities would require capital expenditures of $10.9 million, $14.8 million, and $25.5 million, respectively. The majority of the prospective cost impact is attributable to the design and construction of the very large Subtitle C landfills that would be required to manage this waste. New capital expenditures (as well as new operating expenditures) at the Omaha refinery would be modest, because EPA believes that this facility would continue to ship its slag off-site for disposal, and hence would not experience the costs associated with building an on-site Subtitle C disposal unit (landfill).

Under the facility specific risk-based requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about half of those of the full Subtitle C scenario. Annualized compliance costs under this scenario range from about $0.84 to $2.9 million greater than baseline; the total compliance cost for the sector is approximately $8.7 million over baseline. Compliance-related capital expenditures range from about $1.5 million to more than $11 million, excluding the Omaha refinery. The costs at the Omaha facility, with its off-site disposal needs, are virtually the same under either Subtitle C scenario as the disposal is to an off-site RCRA hazardous waste operation in either case. For the remaining four facilities that all conduct smelting operations, this less restrictive scenario results in a reduction of required capital expenditures of more than 50 percent. The primary reason for the difference in waste management cost is the fact that, while all facilities would be forced to build new environmentally protective disposal units, relaxation of the minimum technology requirements, which changes the configuration of the landfill liner, leachate collection/detection system, and (closure) cap, would substantially reduce the capital expenditures needed. In addition, the Herculaneum facility would be allowed to construct a disposal waste pile rather than a landfill, reducing new capital expenditures by a factor of seven.

Under the Subtitle D-Plus regulatory scenario, compliance-related waste management costs, about $7.6 million over baseline, are about 88 percent of the Subtitle C-minus costs (i.e., a 12 percent savings), though the costs represent a 46 percent savings over the full Subtitle C costs. At ASARCO/Omaha, EPA assumes that the facility will construct an adequately protective land disposal unit (landfill), rather than continue to ship its refinery slag to a commercial disposal facility (disposal in a municipal or industrial solid waste landfill is assumed here to not be adequately protective of the environment). The facility would achieve a cost savings of about two percent, as compared with the Subtitle C-Minus scenario, by adopting this practice. The ASARCO/East Helena facility, with its large volume of waste sent to disposal, would build, as the least cost practice, a disposal landfill that is identical to the landfill required under Subtitle C-Minus; costs under the two scenarios are therefore identical. The other three facilities, because they recycle more and dispose less smelter slag, are assumed to build, as the least cost practice, environmentally protective disposal wastepiles, at a cost savings ranging from 16 to 34 percent, as compared to the Subtitle C-Minus disposal landfills; estimated annualized compliance costs for these facilities range from $0.57 to $2.0 million.

Exhibit 10-12
Compliance Cost Analysis Results for Management of Lead Slag from Primary Processing[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Asarco - East Helena MT	165	5,402	25,546	3,812	2,895	11,395	1,700	2,895	11,395	1,700
Asarco - Glover MO	115	2,805	10,893	1,625	2,416	8,711	1,300	2,016	7,617	1,137
Asarco - Omaha NE	231	1,379	129	19	1,391	191	29	1,354	3,675	548
Doe Run - Boss MO	40	1,464	3,281	490	1,148	1,554	232	744	1,936	289
Doe Run - Herculaneum MO	108	3,549	14,836	2,214	839	2,075	310	571	1,754	262
Total:	659	14,599	54,685	8,160	8,689	23,926	3,570	7,580	26,377	3,936
Average:	132	2,920	10,937	1,632	1,738	4,785	714	1,516	5,275	787

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

10.6.3 Financial and Economic Impact Assessment

To evaluate the ability of affected facilities to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of each facility (in the form of financial impact ratios) to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary lead producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the lead industry. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in a Appendix E-4 to this document, while detailed results are presented in Appendix E-5 (appendices are contained in Volume III).

Financial Ratio Analysis

EPA's compliance cost ratios suggest that all five primary lead operations would be potentially affected under any regulatory scenario, though impacts on the Herculaneum facility would be modest under the Subtitle C-Minus and D-Plus scenarios. These financial ratio results are presented in Exhibit 10-13.

Under the Subtitle C scenario, three of the operations are expected to incur highly significant impacts; annualized compliance costs as a percentage of value added exceed twelve percent at these plants. Ratios at the remaining two plants (Glover and Herculaneum) are more moderate (about nine and five percent, respectively). Impacts at the East Helena smelter are particularly extreme; costs approach 50 percent of value added and annualized capital expenditures to achieve compliance would exceed annual sustaining capital at the facility.

Impacts under the Subtitle C-Minus scenario are generally similar to those of the full Subtitle C scenario, though of somewhat lesser magnitude, with the exception of the Herculaneum facility. The Herculaneum smelter/refinery is assumed to be able to continue to employ a disposal wastepile under this scenario (because it poses only a low risk to ground water); costs, and therefore, impacts, are substantially lower (81 percent) than under the full Subtitle C scenario. ASARCO/Omaha has nearly identical ratio results, because off-site disposal costs are the same under the two Subtitle C scenarios.

In terms of impacts, there are no dramatic differences between the Subtitle C-Minus and Subtitle D-Plus scenarios, though, as discussed above, compliance costs would be reduced at some facilities.

Market Factor Analysis

General Competitive Position

The U.S. lead smelting and refining facilities are among the lowest cost in the world. This stems largely from the fact that the Missouri smelter ore sources are among the only significant primary lead supplies in the world. The fact that the lead is not associated with significant impurities allows for the production of a concentrate (smelter feed) with very high lead content (greater than 70 percent lead). This is far different than most lead concentrates produced by other nations, in which lead levels range from 30 to 55 percent. Concentrates with lower lead content require more flux and coke in the smelting process, and are therefore more expensive to refine.

Looking strictly at smelting and refining costs, however, yields a distorted picture of the overall economics of lead production in the United States. Most foreign primary lead facilities are operated to produce significant quantities of co-products or by-products, meaning that a substantial share of their operating revenues are derived from sales of refined zinc, silver, and/or other metals. The U.S. lead producers have

Exhibit 10-13
Significance of Regulatory Compliance Costs for Lead Slag from Primary Processing[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
ASARCO - East Helena, MT	23.3%	49.9%	105.4%
ASARCO - Glover, MO	5.5%	8.8%	29.5%
ASARCO - Omaha, NE	3.7%	12.2%	0.5%
Doe Run - Boss, MO	11.4%	18.0%	35.0%
Doe Run - Herculaneum, MO	3.4%	5.4%	19.7%
Subtitle C-Minus			
ASARCO - East Helena, MT	12.5%	26.7%	47.0%
ASARCO - Glover, MO	4.8%	7.6%	23.6%
ASARCO - Omaha, NE	3.8%	12.3%	0.7%
Doe Run - Boss, MO	8.9%	14.2%	16.6%
Doe Run - Herculaneum, MO	0.8%	1.3%	2.8%
Subtitle D-Plus			
ASARCO - East Helena, MT	12.5%	26.7%	47.0%
ASARCO - Glover, MO	4.0%	6.3%	20.6%
ASARCO - Omaha, NE	3.7%	12.0%	13.6%
Doe Run - Boss, MO	5.8%	9.2%	20.6%
Doe Run - Herculaneum, MO	0.6%	0.9%	2.3%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Curre Capital Outlays

(a) Values reported in this table are based upon EPA's compliance cost estimate The Agency believes that these values are precise to two significant figures.

minimal by-product revenues and, accordingly, are very dependent upon lead sales for their revenues. Foreign lead facilities may smelt at a high cost but the by-product credits result in a very low allocated lead cost per pound. For this reason, the allocated cost of lead production at many foreign facilities is less than 20 cents per pound, despite total metal smelting and refining costs that range from 10 to 16 cents per pound.

In contrast, smelting and refining costs for Missouri facilities are on the order of 10 - 11 cents per pound of lead, but overall cash costs of lead metal production are in the range of 20 cents per pound. As a result, domestic producers of lead are on the upper end of the supply curve (i.e., are less cost-competitive) as compared to most foreign lead producers.

At 1989 price levels, current production costs (about 20 cents/lb.) are adequate to produce substantial profits for all of the integrated domestic lead producers. If, however, lead prices (in real terms) were to fall back to historical long-range levels, then the operating margins for domestic producers would become very small.

Potential for Compliance Cost Pass-Through

Labor Markets. There has been a considerable reduction in employment levels in the U.S. lead industry throughout the 1980s. In order to remain cost-competitive, reductions in unit costs of both labor and supplies were necessary to avoid permanent closure of several smelter/refinery facilities. It is unlikely that there could be substantially more reductions on the labor rate side or in staffing without affecting operational efficiency.

Raw Material Supply Markets. Since the suppliers of lead smelting and refining industry are primarily company-owned lead mines, there is little opportunity to reduce the price paid for lead concentrate. Some facilities might, however, be able to reduce prices paid to independent mines for concentrates to a limited extent. Beyond a certain price level, however, those concentrates would probably be offered for sale on the world market.

Smelter/refineries not associated with mines would be at a disadvantage in attracting concentrates from foreign sources; they already have high operating costs on a competitive world basis.

Higher Prices. The U.S. lead producers have some limited flexibility in raising prices due to the 1 cent to 4 cent-per-pound cost advantage that they enjoy in shipping to certain areas in the U.S., as compared to foreign lead metal suppliers. This advantage is reflected in the fact that U.S. refined production has recovered significantly from the market downturns of the early 1980s. Domestic primary and secondary lead sources provide almost 90 percent of U.S. requirements. As a result, domestic lead processors may be able to pass through compliance costs to domestic consumers to a limited extent.

Evaluation of Cost/Economic Impacts

EPA expects that all five domestic primary lead operations would suffer significant cost and financial impacts from full Subtitle C regulation of lead slag. Regulation under the Subtitle C-Minus or D-Plus regulatory scenarios would also impose significant impacts at four of the five facilities; waste management costs at the Herculaneum smelter/refinery would not increase as dramatically, due to the environmental characteristics of its location. Given significant waste management cost increases and a very limited potential for compliance cost pass-through, EPA believes that stringent regulation of lead slag as a hazardous waste under RCRA Subtitle C could pose a serious threat to the continued viability of much of the domestic primary lead processing industry.

Estimated compliance costs represent significant portions of the value of shipments and the value added by lead processing operations, and presumably, would at least periodically exceed the operating margins of the lead processors. Initial capital investment requirements exceed $8 million at two facilities under both Subtitle C scenarios and exceed $1.5 million at all smelters under either Subtitle C scenario. EPA believes that some of these facilities might choose not to make these capital investments, and that those that did upgrade their waste management practices might experience difficulty in obtaining external financing.

At the largest primary processing facility, Doe Run's integrated Herculaneum operation, impacts associated with Subtitle C-Minus or D-Plus would be much less than at the other three smelter operations, and would probably not threaten its continued operation. Additionally, should the operators of the ASARCO/Omaha refinery opt to ship their refinery slag to a smelter for recycling rather than to disposal (current practice at the three integrated lead processing facilities), then it would not incur significant impacts if lead slag were to be removed from the Mining Waste Exclusion. Indirect impacts to the Omaha facility would be incurred, however, if the East Helena smelter, the refinery's primary source of unrefined lead bullion, should curtail or suspend operations. In that event, the Omaha facility would either discontinue operations or become a secondary producer.

Even under the relaxed waste management standards of the Subtitle C-Minus or D-Plus scenarios, at least three primary lead processors would probably incur highly significant cost and financial impacts. Unless recycling or reprocessing of the slag could reduce the quantities to be disposed in waste management units, these impacts could threaten the continued viability of these facilities, even in the absence of a decision to remove lead slag from the Mining Waste Exclusion. The Boss facility is already on standby status and new regulatory compliance costs would likely force Doe Run to discontinue operations (even in the absence of new regulations, the U.S. Bureau of Mines estimates that the long-term capacity utilization of this facility is only 20 percent). Closure of ASARCO's East Helena or Glover facilities, on the other hand, which are expected to operate at 80 and 100 percent of capacity, respectively, would have significant repercussions not only on the facilities themselves, but potentially on domestic extraction and beneficiation operations supplying the plants. A portion of the reduced smelting and refining capacity would likely be picked up by secondary processors recycling scrap lead. Although current prices for lead are relatively high, and the domestic producers are operating at a profit, the long-term outlook for primary lead processors is uncertain.

10.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) the potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of lead slag is relatively high compared to the other mineral processing wastes studied in this report. Numerous slag samples analyzed with the EP leach test did exceed the regulatory levels. Lead was measured in EP leachate in excess of the EP regulatory level at all five facilities, in a total of 27 out of 101 samples. Cadmium concentrations exceeded the regulatory level in 7 out of 99 samples (from 2 of 5 facilities tested). Arsenic, mercury, and selenium concentrations measured in EP leachate exceeded the regulatory levels only in samples of refinery slag from the ASARCO refinery in Omaha, NE. Arsenic and selenium exceeded the regulatory levels in roughly 27 out of 94 samples, while mercury exceeded the level in 79 out of 94 samples. None of the slag samples that were analyzed using the SPLP leach test (EPA Method 1312) contained constituents in concentrations above the EP toxicity regulatory levels. In addition to these exceedances of the EP toxicity regulatory levels, lead slag contains 12 constituents in concentrations that exceed the risk screening criteria used in this analysis by more than a factor of 10. All of these factors lead EPA to conclude that lead slag, especially refinery slag, could pose a significant risk if mismanaged.

Based on an examination of existing release and exposure conditions at the five active lead facilities, as well as predictive modeling, EPA concludes that management of lead slag at some sites could allow the migration of contaminants into surface water and ground water in harmful concentrations. At the Glover, East Helena, and Boss facilities, the Agency estimates that, without any run-off controls, erosion from lead slag piles could result in annual average concentrations of arsenic, lead, iron, manganese, and/or zinc in nearby creeks that exceed human health and ecological protection criteria.[59] Although significant releases to ground water appear less likely at most sites because of hydrogeologic conditions, the Agency's modeling indicates that ground water within the facility boundary at Glover and East Helena could be contaminated with cobalt in excess of irrigation guidelines. Ground water on-site at the Glover facility could also be contaminated with arsenic, but the predicted contamination would cause a lifetime cancer risk of only $4x10^{-7}$ if ingested and is likely to remain within the facility boundary for more than 200 years. Air pathway modeling indicates that it is very unlikely that slag piles could cause harmful concentrations of contaminants at the locations of existing residences.

The documented cases of damage associated with lead slag also indicate that management of the slag could cause surface water and ground-water contamination. By collecting data from State and EPA Regional files and personnel, EPA identified documented cases of contamination at three of the five facilities.

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[59] The Glover and Boss facilities, however, presently collect and treat fluids coming from the lead slag piles prior to discharge, making it unlikely for the predicted surface water contamination to actually occur at these sites. It is possible that the contamination could occur in the future if the run-off control systems are not maintained after closure.

Monitoring data show that "surface water seeps" from slag piles at the Glover and East Helena facilities contain arsenic, lead, and/or cadmium in concentrations that exceed drinking water standards. Although these seeps represent largely undiluted leachate and run-off (rather than ambient surface water concentrations) and both facilities have taken steps to reduce run-off, the documented presence of the seeps and their high concentrations support the risk modeling conclusions that run-off, if not controlled, could be an important contributor to surface water contamination. Information collected from the damage case research also suggests that the slag pile at the Boss facility could cause surface water contamination, as predicted by the risk modeling. However, the damage case data suggest more extensive ground-water contamination at the Glover, East Helena, and Boss facilities than is predicted by the modeling, possibly due to the presence of other on-site contaminant sources and additional factors not fully accounted for in the risk modeling.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

As summarized above, current waste management practices and environmental conditions may allow contaminant migration and exposures in the future in the absence of more stringent regulation. Although all of the existing slag piles are located within 1,100 meters of a creek or river (three are within 100 meters of a water body) and four of the five facilities are located in areas with high to moderate precipitation rates, only the slag piles at the Glover and Boss facilities are equipped with storm water run-on/run-off controls. In addition, only the slag piles at the Omaha facility are equipped with a synthetic liner (made of concrete), even though releases to ground water from the slag piles at three other sites are considered possible based on a review of the site conditions, risk modeling results, and damage case findings. Therefore, contaminant migration during the operating life of most units appears possible, and these releases could persist after closure if the units are not closed properly. Considering the intrinsic hazard of the waste, these releases could conceivably cause ecological impacts, as well as significant human exposures if nearby ground or surface water is used.

Because of overall market conditions, EPA believes that the prospect of additional primary lead smelting/refining facilities commencing operation in the U.S. is unlikely. Therefore, EPA believes that it is unlikely that new lead facilities will start up in the future having management practices and environmental conditions different than those considered here. However, the refinery slag from the Omaha facility -- which contains by far the greatest concentration of contaminants of the lead slag analyzed -- is shipped off-site for disposal. EPA has no information on the management controls and environmental conditions at this off-site location, which could be conducive to releases and associated risks. Furthermore, although the slag is presently not used off-site, it has been in the past and conceivably could be again in the future. Any off-site uses, if not properly controlled, could also result in damages in the future.

EPA concludes that current State regulation of lead slag management practices is notably limited in scope. The five existing facilities are located in Montana, Nebraska, and Missouri (three facilities), all of which exclude mineral processing wastes from hazardous waste regulation. Montana classifies lead slag as solid waste, but excludes slag generated at the East Helena facility from solid waste regulatory requirements because the slag is managed on-site. Although not studied in detail for this report, a brief review of Nebraska regulations suggests that this State also does not regulate lead slag as a solid waste. Historically, Missouri has not addressed lead slag under its solid waste regulations. Missouri recently passed a Metallic Minerals Waste Management Act, however, that will apply to generators of lead slag. Until the State drafts regulations to implement this Act and issues permits, it is not clear how comprehensively or stringently Missouri will regulate lead slag. Missouri does require owners/operators to obtain NPDES permits for storm water discharges, and thus to install run-on/run-off controls. As discussed above, however, only the slag pile at the Glover facility is currently equipped with such controls. Montana does not require storm water run-on/run-off controls for lead slag piles, and neither Missouri nor Montana require measures to control fugitive dust emissions from lead slag piles (though based on the risk modeling results, windblown dust from the existing slag piles does not appear to pose a significant inhalation risk). Given these limited state controls, it is questionable if human health and environmental protection will be ensured in the future in the absence of additional Federal regulation.

Costs and Impacts of Subtitle C Regulation

EPA has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. EPA's waste characterization data indicate that lead slag may exhibit the hazardous waste characteristic of EP toxicity at all of the five active facilities. Costs of regulatory compliance under the full Subtitle C scenario exceed $1 million annually at all facilities; these costs would impose potentially significant economic impacts on the operators of all five plants. Application of the more flexible Subtitle C-Minus regulatory scenario would result in compliance costs that are approximately 40 percent lower. Costs under the Subtitle C-Minus and Subtitle D-Plus scenarios are similar (or identical) at three of the five facilities, because adequately protective waste management unit design and operating standards are essentially the same under both scenarios, given the nature of the waste and the environmental settings in which it is currently managed.

These costs would comprise a significant fraction of the value of shipments of and value added by primary lead smelting/refining operations. ASARCO's East Helena smelter and Omaha refinery, and Doe Run's Boss smelter/refinery would suffer particularly pronounced impacts; compliance costs as a percentage of value of shipments approach or exceed ten percent at each of these plants, even under the Subtitle D-Plus regulatory scenario. EPA's economic impact analysis suggests that although the current price of lead is relatively high and domestic producers are operating at a profit, the long-term outlook for the domestic primary lead industry is uncertain. Demand for production of refined lead from virgin sources has been falling in recent years relative to production of secondary lead by recycling of lead-containing products (e.g., automotive batteries). Therefore, EPA believes that the operators of primary lead plants could pass through a portion of any regulatory compliance costs that they might incur to product consumers, but that it is improbable that prices could be raised to a level adequate to completely off-set regulatory compliance costs.

Finally, it is worthy of note that these impacts might occur even in the absence of a decision to remove lead slag from the Mining Waste Exclusion, because adequately protective waste management standards under a Subtitle D program may require the construction of new waste management units, implying significant new capital expenditures.

Finally, EPA believes that incentives for recycling or utilization of lead slag would be mixed if a change in the regulatory status of this waste were to occur. Recycling is currently the predominant management practice that is applied to lead slag. It is possible that tighter regulatory controls on the management of primary lead slag might serve to promote even greater recycling and on-site utilization than has occurred in the recent past, e.g., through slag fuming for zinc oxide recovery. Utilization of lead slag in construction and other off-site applications has been reported, but is not widely practiced at present, primarily due to the availability of substitutes and concerns about environmental impacts arising from such use. It is likely that removing lead slag from the Mining Waste Exclusion and thereby subjecting it to regulation as a hazardous waste would, in practical terms, eliminate the use of this material in construction applications.

Chapter 11
Magnesium Production

The primary magnesium processing industry, as discussed in this report, consists of one anhydrous electrolytic magnesium-producing facility that, as of September 1989, was active and reported generating a special waste from mineral processing: process wastewater from primary magnesium processing by the anhydrous process. Two other primary magnesium producing facilities are operating in the U.S. One uses electrolysis but employs, the hydrous process; the other uses a silicothermic process. Neither facility generates a special waste from mineral processing covered under the Mining Waste Exclusion; therefore, these two facilities, their operations, and the wastes that they generate are not addressed in this report. Information included in this chapter is discussed in additional detail in the supporting public docket for this report.

11.1 Industry Overview

The primary use of magnesium metal is as an alloying element in aluminum-base alloys; these alloys are used in the manufacture of such products as beverage cans and transportation equipment. Casting and extrusions of magnesium-base alloys are used in transportation equipment, power tools, computers, and sporting goods. Additional uses for magnesium metal are in the production of ferrous metal (e.g., iron and steel desulfurization, and production of nodular iron) and non-ferrous metal (used as a reducing agent).[1,2]

The anhydrous electrolytic magnesium production facility is located in Rowley, Utah, and is operated by the Magnesium Corporation of America (Magcorp). The facility initiated operations in 1972 and was modernized in 1976 and 1984. The annual production capacity of the facility is reportedly 36,500 metric tons. The total 1988 production of magnesium at the facility was 29,000 metric tons; therefore, the annual capacity utilization rate was 79.4 percent.[3]

No specific information was found regarding trends at the Utah facility, but, at 142,000 metric tons, 1988 U.S. production of primary magnesium was at its highest level since 1984. In 1989, the estimated U.S. primary production was 150,000 metric tons. Primary producers operated at nearly full capacity by year end 1989.[4] The primary magnesium industry in North America has expanded since 1988 as a new Canadian plant has come on-line[5] and as the Dow Chemical Company in Freeport, Texas has increased its production capacity.[6]

Consumption of primary magnesium has increased significantly since 1986 when it fell to 70,000 metric tons from a 1985 level of 76,000 metric tons. Reported consumption of primary magnesium for 1989 was estimated to be 105,000 metric tons. While the U.S. imports some magnesium for consumption, it remains a net exporter.[7]

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[1] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed.; p. 475.

[2] Bureau of Mines, 1987. Minerals Yearbook, 1987 Ed.; p. 588-9.

[3] Magcorp, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

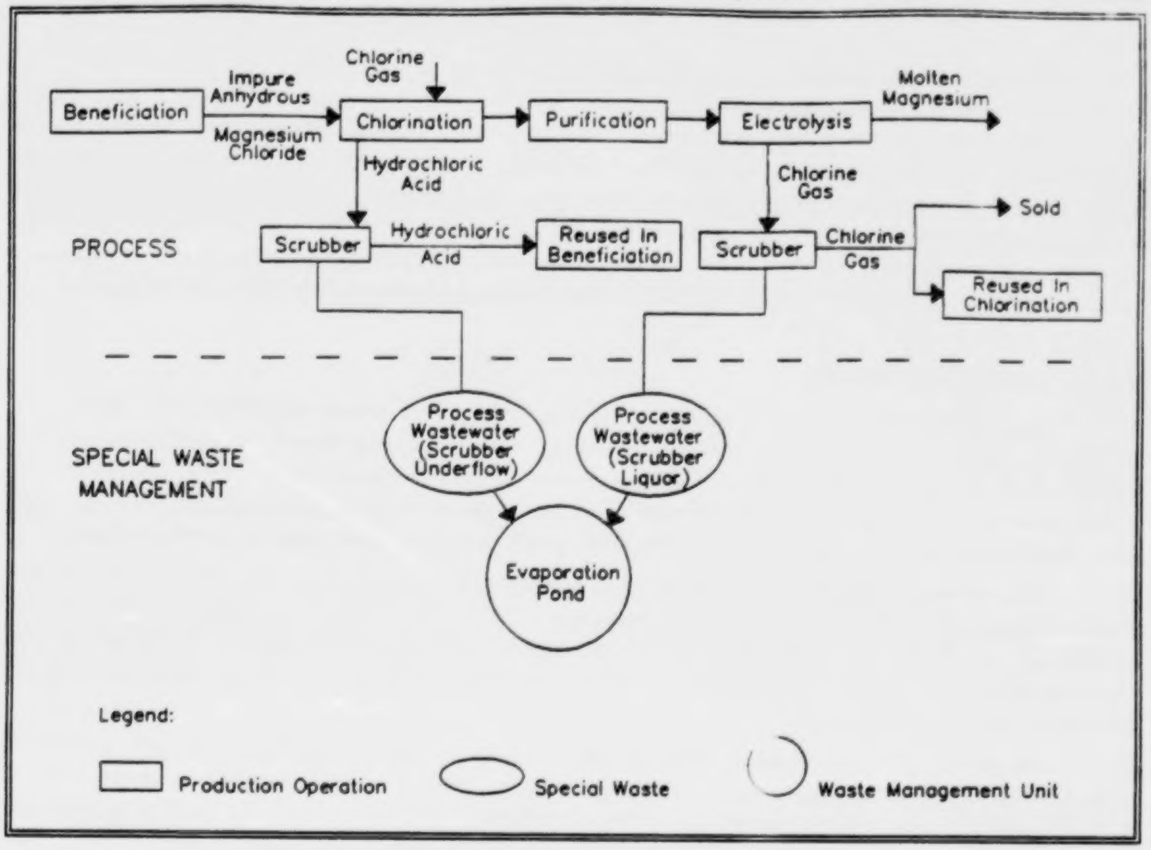
[4] Deborah A. Kramer, U.S. Bureau of Mines, "Magnesium Metal," Mineral Commodity Summaries, 1990 Ed., p. 102.

[5] Ibid., p. 103.

[6] Deborah A. Kramer, U.S. Bureau of Mines, "Magnesium," Minerals Yearbook, 1988 Ed., p. 1.

[7] Kramer, op. cit., p. 102.

Exhibit 11-1
Magnesium Production Using the Anhydrous Process


Chlorine Gas
Impure Anhydrous Magnesium Chloride
Beneficiation
Chlorination
Purification
Electrolysis
Molten Magnesium
Hydrochloric Acid
Chlorine Gas
PROCESS
Scrubber
Hydrochloric Acid
Reused In Beneficiation
Scrubber
Chlorine Gas
Sold
Reused In Chlorination
SPECIAL WASTE MANAGEMENT
Process Wastewater (Scrubber Underflow)
Process Wastewater (Scrubber Liquor)
Evaporation Pond
Legend:
Production Operation
Special Waste
Waste Management Unit

In the anhydrous process used at Rowley, impure anhydrous magnesium chloride powder, which is produced by beneficiation operations performed at the facility,[8] is purified and then magnesium is isolated using electrolysis, as shown in Exhibit 11-1.[9,10] The first purification step is chlorination, which is necessary because during the final beneficiation operation, spray drying, some magnesium oxide is generated that must be converted to magnesium chloride. In this step, the impure magnesium powder is melted in an induction/arc furnace and reacted with chlorine gas in a reaction cell to convert any magnesium oxide to the chloride salt. Hydrochloric acid formed during this chlorination step is sent to scrubbers; the cleaned acid is reused in the beneficiation operations (i.e., for sulfate removal). The scrubber underflow, one source of process wastewater, is disposed in an on-site impoundment. Purification of the magnesium chloride is completed by the addition of other reactants (e.g., ferric chloride, coke, sparge methane) to the molten salt to remove water, bromine, residual sulfate, and heavy metals.[11] A low volume solid (not a special waste from mineral processing), known as smut, is the only waste generated from this final purification operation.

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[8] The beneficiation steps include: concentration of salt brine solution; precipitation of potassium; treatment with calcium chloride for partial removal of sulfates; and removal of boron by phase separation (i.e., solvent extraction) using isooctanol in a kerosene carrier. Upon removal of sulfate and boron from the brine, water is evaporated at 600 degrees centigrade, producing an impure anhydrous magnesium chloride powder.

[9] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Antimony, Magnesium, Tin, and Titanium Smelting and Refining Industries. Prepared by PEI Associates for U.S. EPA, Office of Solid Waste, Washington, D.C., 1984.

[10] Marks, 1978. Encyclopedia of Chemical Technology, Marks, et al., editors; Wiley Interscience, New York, NY, 1978; p. 581.

After purification, molten magnesium chloride is separated into chlorine gas and molten magnesium by applying direct current to the material in electrolytic cells. The purified and separated magnesium metal is vacuumed from the surface of the electrolytic cell bath; the molten metal is then cast into shapes and alloyed in a casting plant.[12] The chlorine gas is removed, scrubbed, cooled, and reused or sold. Stack emissions of chlorine gas arising from this process are significant (approximately one million pounds annually); in fact, the Rowley facility is the nation's largest source of such emissions. The resulting scrubber liquor, which is the second source of process wastewater, is also disposed in the on-site impoundment, along with non-contact cooling water (not a special waste).

11.2 Waste Characteristics, Generation, and Current Management Practices[13]

Approximately 2,465,000 metric tons of process wastewater reportedly were generated by the Rowley facility in 1988.[14] This wastewater contains approximately 2.2 percent solids, consisting predominantly of chlorides, magnesium, sulfate, sodium, calcium, and other metals in trace amounts.

As noted above, the process wastewater is disposed in an on-site impoundment. This impoundment is 1.2 meters (4 feet) deep, has a surface area of about 160 hectares (400 acres), and a volume of nearly 2 million cubic meters. In this impoundment, referred to by the company as the NPDES waste pond, the pH of the process wastewater is reportedly adjusted, though no reagents are added.[15] Solar evaporation and infiltration into the ground are used to reduce the wastewater quantity. There is no discharge to surface water of wastewater from the pond, and no sludge is removed. Process water does not, however, accumulate, nor do any significant volumes of solids settle out of the water in the pond, according to the company.

The impoundment is also used for disposal of several other aqueous wastewaters that are not special wastes from mineral processing operations (e.g., calcium sulfate repulp liquor, calcium chloride thickener underflow, and additional beneficiation wastewaters) and non-contact cooling waters; the latter stream was generated at a volume of approximately 1,060,000 metric tons in 1988.[16]

Using available data on the composition of magnesium process wastewater, EPA evaluated whether the wastewater exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, the Agency does not believe the wastewater is reactive, ignitable, or EP toxic. In fact, all eight inorganic constituents with EP toxicity regulatory levels, with the exception of selenium, are present in concentrations that are at least two orders of magnitude below the regulatory level, that is, below drinking water standards; selenium was not detected in the wastewater. Some wastewater samples, however, exhibit the characteristic of corrosivity. A pH of approximately 1.2, which is below the lower bound corrosivity limit of 2.0, was measured in two out of two samples of magnesium process wastewater at the Magcorp facility. The Rowley facility also reports that the wastewater has an average pH of 1.6.

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[11] Marks, op. cit., p. 581.

[12] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Antimony, Magnesium, Tin, and Titanium Smelting and Refining Industries. Prepared by PEI Associates for U.S. EPA, Office of Solid Waste, Washington, D.C., 1984.

[13] Information provided in this section, unless otherwise noted, is from the response of Amax Magnesium Co. to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities," conducted in 1989.

[14] The corresponding waste-to-product ratio (i.e., metric ton of process wastewater to metric ton of magnesium) was 85.

[15] In comments addressing the October 20, 1988 NPRM (53 FR 41288) (Docket No. – MWEP 00018), AMAX indicated that the oolitic sand, calcium carbonate, provides "a neutralization media for the acidic wastewater."

[16] In comments addressing the October 20, 1988 NPRM (53 FR 41288) and found in the docket (Docket No. – MWEP 00018), AMAX indicated that non-contact cooling water is generated in quantities equalling 43 percent of the quantity of the process wastewater.

11.3 Potential and Documented Danger To Human Health and The Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proved. Overall conclusions about the hazards associated with magnesium process wastewater are provided after these two study factors are discussed.

11.3.1 Risks Associated With Magnesium Process Wastewater

Any potential danger to human health and the environment from magnesium process wastewater is a function primarily of the composition of the wastewater, the practices that are employed to manage it, and the environmental setting of the facility where the wastewater is generated and managed. These factors are discussed separately below.

Constituents of Potential Concern

EPA identified chemical constituents in the magnesium process wastewater that may present a hazard, by collecting data on the composition of wastewater from the Magcorp facility in Rowley and evaluating the intrinsic hazard of the chemical constituents present in the wastewater.

Data on Magnesium Process Wastewater Composition

EPA's characterization of magnesium process wastewater is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW). These data provide information on the concentrations of 20 metals and sulfate in total analyses and EP and SPLP leach test analyses; the concentrations of constituents measured in these three types of analyses are generally consistent.

Process for Identifying Constituents of Potential Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the available data to determine if magnesium process wastewater or leachate from this waste contain any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to screening criteria and then by evaluating the environmental persistence and mobility of constituents that are present at levels above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which the process wastewater constituents are released to the environment and migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and air and surface/ground-water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibit 11-2 presents the results of the comparisons for process wastewater analyses to the screening criteria described above. This exhibit lists all constituents for which the measured concentration exceeds a screening criterion.

Of the 21 constituents analyzed in the process wastewater, only iron, molybdenum, copper, aluminum, and manganese concentrations, as well as pH levels, exceed the screening criteria. Among these constituents, iron, molybdenum, and pH exceed the screening criteria with the greatest frequency and magnitude. For

Exhibit 11-2
Potential Constituents of Concern In Magnesium Process Wastewater(a)

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Screening Criterion	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Iron	2 / 2	Resource Damage	2 / 2
Molybdenum	2 / 2	Resource Damage	2 / 2
Copper	2 / 2	Aquatic Ecological	1 / 2
Aluminum	2 / 2	Aquatic Ecological	1 / 2
Manganese	1 / 2	Resource Damage	1 / 2
pH	2 / 2	Resource Damage	2 / 2

(a) Constituents listed in this table are present in the sample from the facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

example, only iron and molybdenum exceed the screening criteria by a factor of 10 or more. No constituents, however, were detected in concentrations that exceed the EP toxicity regulatory level, though the pH is low enough for the waste to exhibit the hazardous waste characteristic of corrosivity. These concentrations indicate the potential for different types of impacts caused by wastewater seepage.

- If the wastewater is released to ground or surface water and diluted by a factor of 10 or less, iron, molybdenum, and manganese concentrations may be sufficiently high to render the affected ground or surface waters unsuitable for a variety of uses (e.g., direct human consumption, irrigation, livestock watering). The resulting pH levels could also be corrosive.
- Copper and aluminum are present in the wastewater at concentrations that, if released to surface water and diluted by a factor of 100 or less, could exceed criteria for the protection of aquatic life.

These exceedances, by themselves, do not prove that the wastewater poses a significant risk, but indicate that the wastewater may present a hazard under a hypothetical set of release, transport, and exposure conditions. To determine the potential for this waste to cause significant impacts, EPA proceeded to the next step of the risk assessment and analyzed the actual conditions that exist at the facility that generates and manages the wastewater.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of magnesium process wastewater as it was generated and managed at the Magcorp facility in 1988. It does not assess the hazards of off-site use or disposal of the wastewater because this waste is not currently used or disposed off-site, and off-site management or use is not likely in the future. The following analysis also does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on which to base projections of future conditions.

Ground-Water Release, Transport, and Exposure Potential

The waste composition data discussed above indicate that several constituents contained in the magnesium process wastewater (i.e., iron, molybdenum, copper, aluminum, and manganese) are present in concentrations above the screening criteria. However, depending on the pH of the seepage and the receiving aquifer, some of the constituents may not be mobile in ground water. Molybdenum is the only constituent that exceeds the screening criteria that is relatively mobile in ground water under neutral pH conditions. While the pH of the process wastewater in the waste pond is very low (less than 2), it is expected to be neutralized to some extent as the wastewater seeps through the oolitic sand (calcium carbonate) underlying the pond. Nevertheless, the neutralization capacity of the oolitic sand is finite, and in time, acidic seepage could potentially migrate to ground water. Although the ground water does not appear to be acidic at this time,[17] the continued seepage of the acidic wastewater could lower the pH to below 5, and iron, copper, and manganese could also become relatively mobile in the aquifer. Aluminum is relatively immobile in ground water under both neutral and low-pH conditions.

Ground water beneath the Magcorp facility occurs in shallow permeable strata that contain salt waters intruding from the Great Salt Lake and in a deeper aquifer (located 60 meters below the land surface) that is used as a source of livestock water. This deeper aquifer is also saline. The standing quantity of process wastewater in the pond (which is more than 1 meter deep) provides sufficient hydraulic head to drive liquids from the impoundment into the shallow ground water that underlies the facility. Releases to this shallow ground water are not limited by engineered controls such as a liner or leachate collection system, and in fact, infiltration into the ground is purposefully used by the facility and controlled by the State as a way to reduce water volumes. The impoundment, however, is underlain by oolitic sand, which the facility claims neutralizes any wastewater that leaches from the impoundment, and by in-situ clay.

Under these conditions, process wastewater slowly seeps into the shallow ground water beneath the impoundment. The Utah Bureau of Water Pollution Control stated in the NPDES permit for this facility that data presented by Magcorp indicate that seepage from the impoundment has occurred, but that it "was of low volume and did not pose a significant environmental or human health threat."[18] Releases to the deep aquifer are restricted by a fairly continuous clay confining layer, according to local researchers with the U.S. Geological Survey. Therefore, seepage of process wastewater from the impoundment could contaminate the ground water that is hydraulically connected to the Great Salt Lake, but is unlikely to adversely affect the 60-meter deep aquifer that is used for livestock water.

Surface Water Release, Transport, and Exposure Potential

Magnesium process wastewater could enter surface waters by seeping through shallow ground water that is hydraulically connected with the Great Salt Lake (as discussed above), or by direct overland run-off of process wastewater in the event that the impoundment is overtopped or its berms fail. Direct discharges from the impoundment to the lake are prohibited by the NPDES permit for the facility. As discussed above, iron and molybdenum, and to a lesser extent, copper, aluminum, and manganese could pose human health or aquatic ecological threats if discharged to typical receiving waters. The Great Salt Lake is not a typical receiving water, however -- there is no drinking water pathway for human exposure, and it is not clear whether the biota in the Great Salt Lake are more tolerant or less tolerant, compared to most fresh-water species, to elevated concentrations of these metals.

Overland run-off of process wastewater to the Great Salt Lake due to overflow from the impoundment, resulting from excessive precipitation or berm failure, is limited by storm water run-on/run-off controls at the unit, the low precipitation in the area (36 cm/year), and relatively small maximum snow accumulation (26 cm). Furthermore, inundation of the wastewater pond by waters from the Great Salt Lake is unlikely because the pond berms have been raised (up to 10 meters) to safeguard against this possibility.[19] Nevertheless, contaminants from the process wastewater could migrate to the lake by discharge of ground water from the shallow aquifer. Because the lake water is not used for consumptive purposes, surface water releases pose no health threats from drinking water exposures, though recreational use of the lake could potentially pose health threats. Aquatic life (i.e., brine shrimp) also may be adversely affected by any releases of magnesium process wastewater to the lake.

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[17] As a condition of the company's NPDES permit, Magcorp is required to monitor ground water quarterly and report any pH excursions outside the range of 6.5 to 9.0. To the best of EPA's knowledge, no excursions have been reported as of this writing.

[18] Utah Division of Environmental Health (DEH), Bureau of Water Pollution Control, 1989. Statement of Basis for Utah Pollutant Discharge Elimination System Permit No. UT0000779.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern are non-volatile, magnesium process wastewater contaminants can only be released to air in the form of wind-blown particles (dust). The physical form of the wastewater essentially precludes any particle releases to air. In principle, dry deposits could be formed at the edges of the pond when the process wastewater is evaporated to reduce its volume, and dust releases from these deposits at the rim of the impoundment could occur (i.e., particles could be blown into the air by wind). However, the potential for significant airborne release and exposure is expected to be negligible because the area of dry salt deposits is expected to be relatively small as long as the impoundment is active. After closure, however, there may be dusting if the impoundment is dried and the remaining residue is not covered.

Proximity to Sensitive Environments

Other than the Great Salt Lake, which is used for recreational purposes, the Magcorp facility is not located in or near environments that are especially vulnerable to contaminants or that have high resource value (e.g., wetlands, endangered species habitats) that may warrant special consideration.

Risk Modeling

Based upon the evaluation of intrinsic hazard and the descriptive analysis of factors that influence risk presented above, and upon a review of information available on documented damage cases (presented in the next section), EPA has tentatively concluded that the potential for process wastewater from primary magnesium production by the anhydrous process to impose significant risk to human health or the environment if managed according to current practice is low. This conclusion is supported by low risk estimates developed from the Agency's modeling of other mineral processing wastes that appear to pose a greater hazard than magnesium process wastewater. Therefore, the Agency has not conducted a quantitative risk modeling exercise for this waste. (See sections 11.3.3 and 11.7 below for further discussion.)

11.3.2 Damage Cases

State files were reviewed in an effort to document the performance of waste management practices for process wastewater from primary magnesium processing by the anhydrous process for Magcorp's facility in Tooele County, Utah. The file reviews were combined with interviews with State regulatory staff. EPA found no documented environmental damages associated with process wastewater management units at this facility. Nonetheless, as noted above, a study performed by the facility indicates that seepage from the impoundment does occur, but the Utah Division of Environmental Health, Bureau of Water Pollution Control has concluded that "the seepage was low volume and that it didn't pose any real human health or significant environmental threat."[20] In addition, releases from previous impoundments to the Great Salt Lake have occurred in the past when the impoundments have been flooded by the lake due to high lake levels and storm conditions, but the impacts of the releases have not been documented.

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[19] The pond currently in use was located on high terrain and constructed with large berms because impoundments used in the past that were closer to the lake were flooded due to high lake levels and storm conditions.

[20] Utah DEH, 1989, op. cit.

11.3.3 Findings Concerning the Hazards of Magnesium Process Wastewater

The available data indicate that wastewater is being released from the impoundment used for wastewater disposal at the Rowley facility, but the potential danger to human health or the environment, if any, is low due to the location of the impoundment and the characteristics of the wastewater. Specifically, releases to the deep, useable aquifer are restricted by a fairly continuous clay confining layer. Only a few contaminants exceeded the screening criteria and releases from the impoundment to the Great Salt Lake via ground water or overland flow are unlikely to result in harmful concentrations in the Lake. In addition, the pH of the seepage is being monitored under the conditions of a State permit (see below) that also requires seepage to be prevented if the required monitoring indicates the pH is outside of the acceptable range (6.5 to 9).

Although the wastewater is corrosive, the low concentrations of toxic constituents, the evaluation of the release, transport, and exposure pathways, and the absence of any documented cases of danger to human health or the environment, lead EPA to tentatively conclude that the hazard posed by process wastewater from primary magnesium production by the anhydrous process as currently managed is relatively low. As a result, only limited discussions of alternative management practices, utilization, and costs and impacts are provided below. The discussion of costs includes the potential costs of regulation under Subtitle C of RCRA because the waste does exhibit the hazardous waste characteristic of corrosivity.

11.4 Existing Federal and State Waste Management Controls

11.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology-based limitations," which provide the basis for minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT and BAT requirements for magnesium production specify that there shall be no discharge of process wastewater pollutants to navigable waters (40 CFR 436.120).

EPA is unaware of any other federal management control or pollutant release requirements that apply specifically to this wastewater stream.

11.4.2 State Regulation

The single primary magnesium processing facility currently active in the United States and addressed by this report is located in Rowley, Utah. The State of Utah excludes the process wastewater generated by this facility from both hazardous and solid waste regulation. Utah does have an approved NPDES program, however, and requires that the Rowley facility maintain a no discharge permit for its process wastewater surface impoundment. Under the terms of this permit, the facility owner/operator must monitor pH both in ground water and any standing surface water adjacent to the impoundment, and if pH levels are outside of the range of 6.5 to 9.0, notify the state and EPA immediately. The state is aware that some seepage from the surface impoundment may be occurring, but has concluded that the seepage has not caused adverse environmental affects. Utah recently enacted new ground-water protection legislation that might address the process wastewater managed at the Rowley facility, though the state has not yet issued any permits.

11.5 Waste Management Alternatives and Potential Utilization

Wastewater management alternatives are generally limited in scope to strategies for recycling, treating, and/or disposing of the material. In the case of process wastewater from primary magnesium production, EPA believes that management alternatives consist primarily of treating the wastewater (i.e., pH adjustment), and either discharging the treated effluent to the existing evaporation impoundment or recycling it to the magnesium production operation. Sludge generation as a result of such treatment would depend on the pH of the treated wastewater and the treatment agent(s) employed. If sludge is generated by this management scheme, it might require disposal in a RCRA Subtitle C facility (due to heavy metal content). The costs associated with this waste management alternative are examined below in section 11.6.

11.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste management units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C, if land disposal restrictions had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed under different regulatory scenarios by Magcorp's primary magnesium production facility in Rowley, Utah. Next, the section discusses the cost implications of requiring these changes to existing waste management practices. The last part of the section predicts and discusses the ultimate impacts of any increased waste management costs faced by the facility.

11.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented above, EPA believes that process wastewater from the Rowley facility poses a low degree of hazard; the waste does, however, exhibit the hazardous characteristic of corrosivity, based on EPA and industry sampling data. Accordingly, the Agency has estimated the costs associated with regulation under Subtitle C of RCRA, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D" (a more detailed description of the cost impact analysis and the development of these regulatory scenarios is presented in Chapter 2, above). In the following paragraphs, EPA discusses the assumed management practices that would occur under each regulatory alternative.

Subtitle C

Under Subtitle C standards, hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because magnesium anhydrous process wastewater is a dilute, aqueous liquid that is corrosive but not EP toxic, the management practice of choice under Subtitle C is treatment (neutralization) in a tank. EPA has determined that within the relevant size range, tank treatment is the least-cost management method, and has conducted its analysis accordingly. The scenario examined here involves construction of a Subtitle C surge pond (double-lined surface impoundment), and a tank treatment system. Following neutralization, the treated process wastewater may be reused by the facility or discharged to the existing surface impoundment, just as it is under current practice. The treatment sludge, which is assumed to not be a hazardous waste, is disposed in an unlined disposal impoundment/landfill.

Subtitle C-Minus

Assumed practices under Subtitle C-Minus are identical to those described above for the full Subtitle C scenario, with the exception that some of the strict requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements. Because other Subtitle C provisions apply in full, there are no significant operational differences between the two scenarios.

Subtitle D-Plus

Assumed practices under Subtitle D-Plus are identical to those described above for the full Subtitle C scenario, with the exception that, as under Subtitle C-minus, some of the strict requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements. Because other provisions that are analogous to Subtitle C controls apply under this scenario, there are no significant operational differences between this and the other two scenarios.

11.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the magnesium anhydrous processing sector are presented by regulatory scenario in Exhibit 11-3. Under the Subtitle C scenario, annualized incremental regulatory compliance costs are estimated for Magcorp's Rowley facility to be $1.23 million greater than baseline (over 4 times the baseline costs). Annualized incremental capital compliance expenditures are estimated at $286,000, or approximately 23 percent of the total incremental compliance costs.

Under the somewhat less rigorous requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are lower, due to decreased capital construction outlays. Magcorp's annualized compliance costs under this scenario are estimated to be $1.18 million greater than baseline (about 4 times baseline costs). The

Exhibit 11-3
Compliance Cost Analysis Results for Management of Process Wastewater from Primary Magnesium Processing by the Anhydrous Process[(a)]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Magcorp - Rowley, UT	368	1,231	1,918	286	1,183	1,668	249	1,183	1,668	249
Total:	368	1,231	1,918	286	1,183	1,668	249	1,183	1,668	249

(a) Values reported in this table are those computed by EPA's cost-estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

total compliance cost for the sector is only about three percent less than under the full Subtitle C scenario. The primary reason for the difference in waste management costs is the configuration of the surge pond liner system; under the Subtitle C-Minus scenario, disposal units are equipped with a single synthetic liner and leachate collection system, rather than the dual system required under full Subtitle C regulation.

Costs under the Subtitle D-Plus regulatory scenario are identical to those under Subtitle C-Minus scenario. The configuration of the surge pond, the only varying factor between Subtitle C and C-minus, is the same for D-Plus and C-Minus (installation of a composite liner with clean closure).

11.6.3 Financial and Economic Impact Assessment

To evaluate the ability of the affected facility to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, to assess the magnitude of the financial burden that would be imposed in the absence of changes in magnesium supply, demand, or price, the Agency calculated financial impact ratios by comparing the estimated compliance costs to several measures of the financial strength of the facility. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary magnesium producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the facility. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in Appendices E-3 and E-4 (in Volume III) to this report.

Financial Ratio Analysis

EPA's ratio analysis indicates that regulation under any of the three scenarios would impose marginally significant impacts on the one affected facility. The costs associated with management of process wastewater under Subtitle C represent around one percent of value added (which in this case is the equal to value of shipments), as shown in Exhibit 11-4. The only potentially significant impact is that of the required annualized compliance capital as a percentage of current total annual sustaining capital investments; additional capital above and beyond sustaining capital would be required to cover increased capital needs. The values of this ratio are somewhat deceptive, however, since capital compliance costs are relatively low in magnitude ($250,000 to $286,000 annually). The results of the ratio analysis are high because sustaining capital, the denominator in the ratio analysis, is relatively small because the plant and equipment used in the anhydrous process do not require high levels of continual capital investments.

Market Factor Analysis

General Competitive Position

The United States imports little magnesium metal, most of it coming from Norway and Canada, and is a net exporter of the metal. There are three companies producing magnesium metal in the United States. Magcorp recovers magnesium from Great Salt Lake brines in Utah; Dow from seawater in Texas; and Northwest Alloys from dolomite in Washington state. Domestic production of magnesium metal increased in 1988, with some facilities running at 100 percent of capacity. Production of magnesium metal from primary processing facilities totaled 156,500 short tons in 1988 and overall, producers operated at 91 percent of the industry's rated capacity. The estimated capacity for the sector will increase from 172,000 short tons in 1988 to 181,000 short tons in 1989. In addition, nearly 50,000 tons of raw and old scrap were recovered. These trends are related to recent increases in U.S. demand for magnesium, which have also led to price increases and temporary shortages.

Exhibit 11-4
Significance of Regulatory Compliance Costs for Mangement of Process Wastewater from Primary Magnesium Processing by the Anhydrous Process[(a)]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Magcorp - Rowley, UT	1.3%	1.3%	9.5%
Subtitle C-Minus			
Magcorp - Rowley, UT	1.2%	1.2%	8.2%
Subtitle D-Plus			
Magcorp - Rowley, UT	1.2%	1.2%	8.2%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Potential for Compliance Cost Pass-Through

Labor Markets. Approximately 450 people were employed in the U.S. in the primary production of magnesium metal, though the number employed at Rowley is not known. The average salary was $26,652 per year. It is unlikely that there could be reductions in labor rates or staffing that could substantially mitigate higher compliance costs.

Supply Markets. Magnesium is an abundant element and is primarily extracted from seawater and well and lake brines. The supply of these materials is extremely low-cost, and free in many cases (e.g., brines from the Great Salt Lake). For the affected facility, therefore, there is essentially no supply market that could be induced to share any incremental compliance cost burden.

Higher Prices. Because only one of the three domestic producers would be subject to compliance costs, higher prices would not be expected as a result of compliance. However, due to high capacity utilization, it is unlikely that producers would be able to increase supply if demand were to rise. Therefore, if demand for magnesium metals continues to increase, prices may rise somewhat. There is little foreign competition in this sector, so overseas supplies are unlikely to displace U.S.-made magnesium.

Evaluation of Cost/Economic Impacts

EPA believes that stringent regulation of magnesium process wastewater as a hazardous waste would not impose highly significant economic or financial impacts on Magcorp's facility in Rowley, Utah. Estimated Subtitle C compliance costs are moderate, though a large capital investment relative to current sustaining capital would be required. Because of the strength of the domestic facilities in the magnesium market and high current capacity utilization across the sector, EPA believes that facilities in the magnesium production industry might be able to increase prices somewhat without seriously undercutting sales. Furthermore, EPA's analysis suggests that Magcorp (the only facility that generates a special waste) could pass through a portion of any regulatory compliance costs to product consumers, because demand for and prices of magnesium have been strong in recent years, and are expected to remain so for the foreseeable future. Consequently, EPA believes that regulation of process wastewater from magnesium production by the anhydrous process under RCRA Subtitle C would not threaten the long-term profitability or economic viability of the Magcorp facility.

11.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of magnesium process wastewater is high to moderate as compared to the other mineral processing wastes studied in this report. Measurement of pH for two samples of the process wastewater indicate that the wastewater exhibits the hazardous waste characteristic of corrosivity, with a pH of approximately 1. However, magnesium process wastewater contains only two constituents that exceed one or more of the screening criteria used in this analysis by more than a factor of 10.

Despite the relatively high to moderate intrinsic hazard of this waste, current management practices and environmental conditions appear to limit the potential for the wastewater to threaten human health or the environment. Migration of contaminants from the wastewater pond has been observed, but the Utah Bureau of Water Pollution Control has stated that the seepage "was of low volume and did not pose a significant environmental or human health threat." This is partly because shallow ground water at the Rowley site is saline and unuseable (it is hydraulically connected with the Great Salt Lake), and partly because the pond is underlain by oolitic sand that may neutralize the low pH of the seepage. The pH of the seepage is being monitored under the conditions of a State permit that requires the seepage to be prevented if monitoring indicates that the pH is outside the acceptable range of 6.5 to 9. In addition, only a few constituents of the wastewater were present at concentrations that exceeded the screening criteria. Consequently, it is unlikely that releases from the impoundment would result in harmful contaminant concentrations in the Lake or underlying aquifers.

The finding that the potential for danger to human health and the environment is generally low is confirmed by the absence of documented cases of environmental damage. Releases of wastewater to the Great Salt Lake have occurred in the past when rising lake levels flooded the impoundment used for wastewater evaporation. The current impoundment, which was constructed to replace the flooded impoundment, has higher and thicker dikes to prevent flooding by the lake.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

While the relatively high to moderate intrinsic hazard of the wastewater is unlikely to change in the future, the waste management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment are expected to continue to limit risks in the future in the absence of Subtitle C regulation. Despite the fact that this analysis is limited to the single site at which the waste is currently managed, EPA believes that the conclusion of low hazard can be extrapolated into the future because the environmental conditions in which the wastewater is managed are unlikely to change. Management of the process wastewater is unlikely to expand beyond the location studied for two reasons. First, the quantity of material involved makes it unlikely that the process wastewater would be managed off-site. Second, development of new facilities in substantially different environmental settings is unlikely because the Great Salt Lake provides the feedstock necessary for magnesium production by the anhydrous process.

The potential for increased risks in the future is further restricted by State regulation of the wastewater evaporation impoundment. Although the State of Utah excludes mineral processing wastes generated at the Rowley facility from hazardous waste regulation, the State has required that the facility maintain an NPDES no-discharge permit for its process wastewater surface impoundment and is tracking the seepage from the impoundment, as discussed above. The State recently enacted new ground-water protection legislation, and plans to consider the need for a ground-water discharge permit at the Rowley facility, though the effect of such permit requirements on the management of the surface impoundment is not clear.

Costs and Impacts of Subtitle C Regulation

Because EPA waste sampling data indicate that process wastewater from primary magnesium production by the anhydrous process exhibits the hazardous waste characteristic of corrosivity, the Agency has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. As with the other aspects of this study, the Agency's cost and impact analysis is limited in scope to the facility at Rowley, Utah.

Costs of regulatory compliance exceed $1.1 million annually under each of the three regulatory scenarios. Costs under the full Subtitle C, Subtitle C-Minus, and Subtitle D-Plus scenarios are almost identical, because adequately protective waste management unit design and operating standards are essentially the same under all three scenarios, given the nature of the waste and the environmental setting in which it is currently managed. EPA's economic impact analysis suggests that the operator of the potentially affected facility (Magcorp) could pass through a portion of any regulatory compliance costs that it might incur to product consumers, because demand for and prices of magnesium have been strong in recent years. Because the costs of Subtitle C regulatory compliance would not impose significant immediate impacts on the affected facility (less than one and a half percent of value added) and because the facility may have some ability to pass any such costs through to product consumers through higher prices, EPA does not believe that a decision to regulate process wastewater under Subtitle C would threaten the long-term profitability or viability of the Rowley facility.

Finally, EPA is not aware of any significant recycling or utilization initiatives that would be hampered by a change in the regulatory status of this waste. The process water is likely to be managed in much the same way as it is currently, with the exception that it would be treated prior to discharge to the existing surface impoundment. EPA does not believe that additional waste management requirements would materially influence the production processes employed at or general operation of the affected facility.

Chapter 12
Phosphoric Acid Production

The phosphoric acid production industry consists of 21 facilities that were active as of September 1989,[1] employed the wet phosphoric acid production process, and generated two special wastes from mineral processing: process wastewater and phosphogypsum. The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

12.1 Industry Overview

There are two processes for producing phosphoric acid: (1) the wet process, which is a mineral processing operation and is studied here, and (2) the furnace process. Furnace process phosphoric acid production uses elemental phosphorus rather than beneficiated phosphate rock as a feedstock and, therefore, wastes generated by the process are not mineral processing special wastes according to the Agency's definition of mineral processing. Consequently, furnace process production of phosphoric acid is not within the scope of this report.

About 95 percent of the commercial phosphoric acid produced by the wet process is used in the production of fertilizers and animal feed, with a small portion used as a feedstock in chemical processing operations.[2] Typically, the fertilizer and feed plants are co-located with the phosphoric acid facilities.

As shown in Exhibit 12-1, the majority of the 21 active wet process facilities are located in the southeast, with 12 in Florida, three in Louisiana, and one in North Carolina. Production data and dates of initial operation and modernization were provided by all 21 facilities, although two claimed confidential status for their information. The dates of initial operation for the 19 non-confidential facilities ranges from 1945 to 1986.[3] Most of these facilities have undergone modernization within the last ten years, although six facilities have not been upgraded in over 20 years. The 19 reporting non-confidential facilities have a combined annual production capacity of over 11 million metric tons and a 1988 aggregate production of nearly 8.5 million metric tons; the 1988 capacity utilization rate, therefore, was approximately 77 percent. Several facilities, however, operated at low utilization rates (i.e. three facilities reported rates of 15.8, 30.1 and 37.5 percent).

The fertilizer industry, the largest user of phosphoric acid, suffered poor financial conditions for much of the 1980s. These conditions were the result of low domestic demand and reduced foreign buying. Domestic demand for phosphoric acid was boosted by the 1988 recovery of the farm economy and was expected to continue to grow as crop prices and planted acreage increased in 1989. Non-fertilizer uses of phosphoric acid declined during the 1980s due to strict regulations governing the use of phosphates in household products and a decline in industrial demand.[4]

The wet process consists of three operations: digestion, filtration, and concentration, as shown in Exhibit 12-2.[5] Beneficiated phosphate rock is dissolved in phosphoric acid; sulfuric acid is added to this solution and chemically digests the calcium phosphate. The product of this operation is a slurry that consists

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[1] At least two facilities were on standby in 1988, Agrico's Ft. Madison, Iowa and Hahnville (Taft), Louisiana facilities; they are not included in this analysis.

[2] Bureau of Mines, 1987. Minerals Yearbook, 1987 Ed., p. 676.

[3] Phosphoric acid producers, 1989. Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S.EPA, 1989.

[4] Standard & Poor's, "Chemicals: Basic Analysis," Industry Surveys, October 13, 1988 (Section 3), p. C20.

[5] Environmental Protection Agency, 1986. Evaluation of Waste Management for Phosphate Processing. Prepared by PEI Associates for U.S. EPA, Office of Research and Development, Cincinnati, OH, August, 1986.

Exhibit 12-1
Wet Processing Phosphoric Acid Plants

Operator	Location	Parent Company
Agrico	Donaldsonville, LA	Freeport-McMoRan Res. Part.
Agrico	Mulberry (Pierce), FL	Freeport-McMoRan Res. Part.
Agrico	Uncle Sam, LA	Freeport-McMoRan Res. Part.
Arcadian	Geismar, LA	(same as operator)
Central Phos.	Plant City, FL	CF Industries
CF Chemicals	Bartow (Bonnie), FL	(same as operator)
Chevron Chem.	Rock Springs, WY	Chevron Corp.
Conserv	Nichols, FL	(same as operator)
Farmland Ind.	Bartow (Pierce), FL	(same as operator)
Fort Meade Chem.	Fort Meade, FL	US Agri-Chem and WR Grace
Gardinier	Riverview (Tampa), FL	(same as operator)
IMC Fertilizer	New Wales (Mulberry), FL	(same as operator)
Mobil Mining	Pasadena, TX	Mobil Oil Corp.(Mobil Corp.)
Nu-South Ind.	Pascagoula, MS	Nu-West Industries
Nu-West	Soda Springs (Conda), ID	(same as operator)
Occidental Chem.	White Springs, FL	Occidental Petroleum
Royster	Mulberry, FL	Cedar Holding Co.
Royster	Palmetto (Piney Pt), FL	Cedar Holding Co.
Seminole Fert.	Bartow, FL	(same as operator)
JR Simplot	Pocatello, ID	(same as operator)
Texasgulf	Aurora, NC	(same as operator)

of the phosphoric acid solution and a suspended solid, calcium sulfate, commonly known as phosphogypsum. The slurry is routed to a filtration operation where the suspended phosphogypsum is separated from the acid solution. The acid isolated during filtration is concentrated through evaporation to produce "merchant-grade" (54 percent) phosphoric acid. The phosphogypsum is re-slurried, this time in recycled process wastewater, so that it can be pumped to the disposal area. In addition to the large volume of phosphogypsum generated by the wet process, large volumes of process wastewaters are produced, primarily from phosphogypsum transport, phosphoric acid concentration, and process temperature control and cooling. These wastewaters are managed in impoundments and primarily recycled, although some facilities have permits to discharge wastewaters to ground water or surface water.[6]

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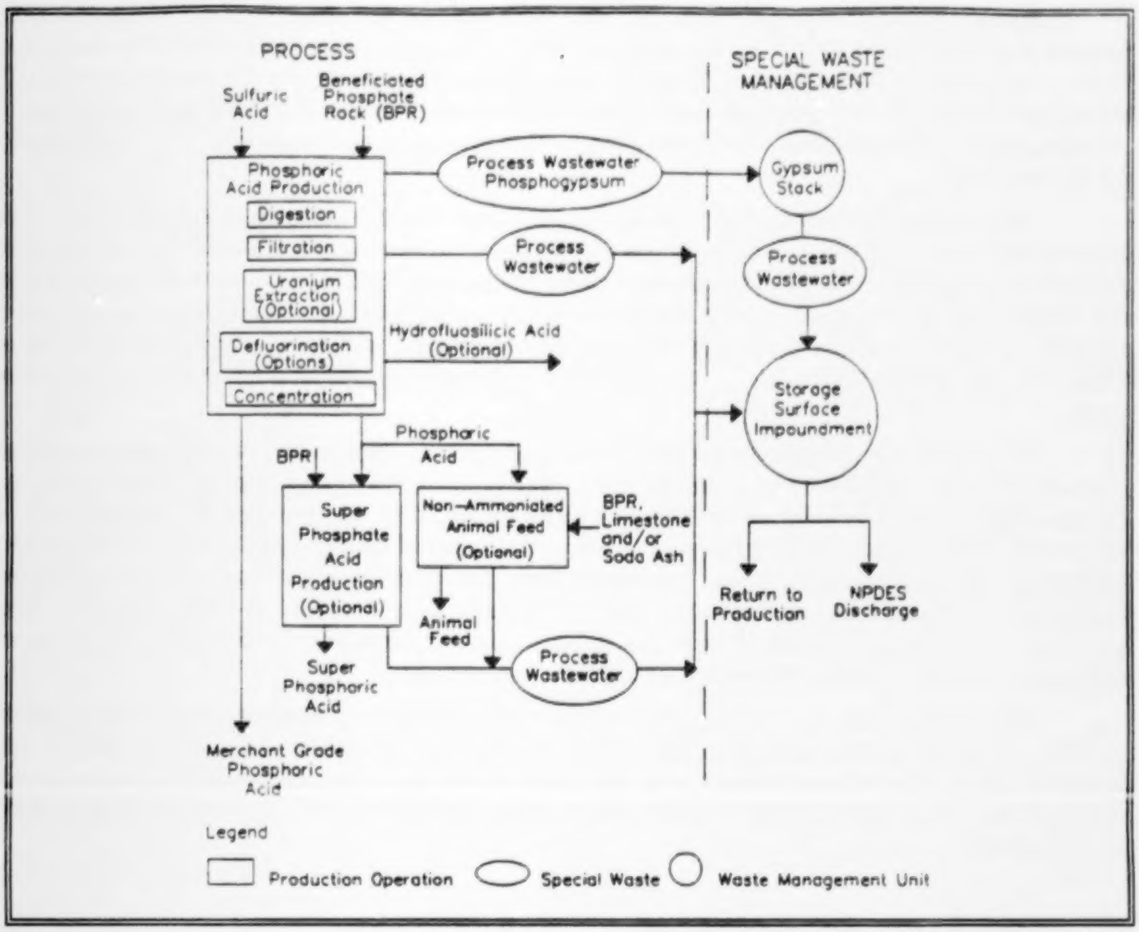
[6] As discussed in detail in the preamble to the final rule that retained the exclusion from RCRA Subtitle C regulations for process wastewater (see 55 FR 2322, January 23, 1990), these are not the only sources of process wastewater. "Process wastewater from phosphoric acid production" also includes phosphogypsum stack runoff, process wastewater generated from the uranium recovery step of phosphoric acid production, process wastewater from animal feed production (including defluorination but excluding ammoniated animal feed production), and process wastewater from superphosphate production.

Exhibit 12-2
Phosphoric Acid Production


PROCESS
SPECIAL WASTE MANAGEMENT
Sulfuric Acid
Beneficiated Phosphate Rock (BPR)
Phosphoric Acid Production
Digestion
Filtration
Uranium Extraction (Optional)
Defluorination (Options)
Concentration
Process Wastewater Phosphogypsum
Gypsum Stack
Process Wastewater
Process Wastewater
Hydrofluosilicic Acid (Optional)
Storage Surface Impoundment
Phosphoric Acid
BPR
Super Phosphate Acid Production (Optional)
Non-Ammoniated Animal Feed (Optional)
BPR, Limestone and/or Soda Ash
Return to Production
NPDES Discharge
Animal Feed
Super Phosphoric Acid
Process Wastewater
Merchant Grade Phosphoric Acid
Legend
Production Operation
Special Waste
Waste Management Unit

12.2 Waste Characteristics, Generation, and Current Management Practices

12.2.1 Phosphogypsum

Phosphogypsum, which has an average particle diameter of less than 0.02 millimeters, is primarily composed of calcium sulfate, silicon, phosphate, and fluoride. It also typically contains a variety of radionuclides, including uranium-230, uranium-234, thorium-230, radium-226, radon-222, lead-210 and polonium-210.

Using available data on the composition of phosphogypsum, EPA evaluated whether leachate from this material exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, the Agency does not believe phosphogypsum is reactive, corrosive, or ignitable. Some phosphogypsum samples, however, exhibit the characteristic of EP toxicity. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for 28 phosphogypsum samples from 11 facilities of interest. Of these constituents, only chromium concentrations exceed the EP toxicity levels; this occurred in 2 of 28 samples analyzed, by as much as a factor of 9. Both samples that failed the EP toxicity criterion for chromium were from the Rock Springs facility. The phosphogypsum samples that failed the EP toxic level were also analyzed using the SPLP leach test, and for both samples, concentrations of chromium measured by the SPLP leach test were well below the EP toxicity regulatory levels.

Non-confidential waste generation rate data were reported for phosphogypsum by 18 of the 21 processing facilities and estimated for the remaining three. The aggregate annual industry-wide generation of phosphogypsum was approximately 47.6 million metric tons in 1988, yielding a facility average of about 2.26 million metric tons per year. Reported facility generation rates ranged from .14 to 6.8 million metric tons of phosphogypsum. The sector-wide ratio of phosphogypsum to phosphoric acid ranges from 3.7 to 5.6, averaging 4.9 for the sector.

Phosphogypsum is managed in basically the same way at virtually all of the 21 active facilities. The phosphogypsum removed by the filtration step in the phosphoric acid production process is slurried in process wastewater and pumped to one or more impoundments located on the top of an on-site waste pile known in the industry as a gypsum stack. In the impoundment, the gypsum solids are allowed to settle; the liquid (process wastewater) is either directly removed from the settling pond and sent to a nearby cooling pond or indirectly removed after it seeps though the stack and is collected by ditches or ponds that circumscribe the stack.

Periodically, the phosphogypsum slurry is diverted from one impoundment on the gypsum stack to another and the first impoundment is allowed to dry. The dewatered phosphogypsum is excavated from the inactive pond and used to build up the dike that forms the impoundment and then the impoundment is returned to active service. In this manner, the stack with its series of settling ponds increases in height and accumulates additional phosphogypsum. The ultimate height and area of the resulting stack depends on the configuration of the facility's property and the ability of the native soils to support the load of the stack. After a stack is "full", rainwater that runs off or leaches through the stack continues to be collected in the perimeter ditch and is usually managed with water collected from active stacks.

The average dimensions of the gypsum stacks are 130 hectares [illegible]20 acres) at the base and 35 meters (115 feet) in height; on a facility-specific basis the stacks range from about 20 to 260 hectares and 3 to 130 meters in height. The average dimensions of the settling ponds atop these stacks are 54 hectares and 1.4 meters in depth; on a facility-specific basis the ponds range in size from 2.6 to 26 hectares and in depth from .3 to 7.6 meters.

12.2.2 Process Wastewater

Process wastewaters are generated at several points in phosphoric acid production, including phosphoric acid concentration, and phosphoric acid temperature control and cooling. These wastewaters contain significant quantities of chloride, fluoride, phosphate, and have a pH that ranges from 0.5 to 7.8.

Using available data on the composition of phosphoric acid process wastewater, EPA evaluated whether the wastewater exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, the Agency does not believe the wastewater is reactive or ignitable. Some wastewater samples, however, exhibit the characteristics of corrosivity and EP toxicity. Measurements of pH in 42 out of 68 process wastewater samples from a total of 14 facilities indicated that the wastewater was corrosive, sometimes with pH values as low as 0.5 (the lower bound pH limit for the purpose of defining corrosive waste is 2.0). EP leach test concentrations of all eight constituents with EP toxicity regulatory levels are available for process wastewaters from 7 facilities. Of these constituents, cadmium and chromium concentrations were found to sometimes exceed the EP toxicity levels, and one sample was found to have a selenium concentration equal to the EP toxicity regulatory level. Concentrations of cadmium exceeded the EP toxic level in process wastewater samples from three facilities, Pocatello, Geismar, and Aurora. Cadmium was present at concentrations in excess of the EP toxic level in 19 out of 30 samples by as much as a factor of 8. From a total of 30 samples, chromium concentrations exceeded the EP toxicity regulatory level (by as much as a factor of 2.7) in only 3 samples (2 of which were from the Pocatello facility and 1 from the Pascagoula facility). SPLP leach test results for phosphoric acid process wastewater samples were well below the EP toxicity regulatory levels for all constituents.

Non-confidential waste generation rate data were fully reported for process water by 12 of the 21 processing facilities and estimated for the remaining nine. The aggregate annual industry-wide generation of process water was approximately 1.77 billion metric tons (468 billion gallons) in 1988, yielding a facility average of 84 million metric tons per year (60 million gallons per day [mgd]). Reported facility annual generation rates ranged from 13 to 280 million metric tons of process wastewater (9.3 to 200 mgd). The ratio of process water managed to phosphoric acid produced ranges from 102 to 494.

The process wastewater from the stacks, along with non-transport process waters, are typically managed in on-site impoundments, commonly known as cooling ponds. These impoundments are used in conjunction with the gypsum stacks in an integrated system. Water from these ponds is reused in on-site mineral processing and other activities. The facility operators ideally seek to maintain a water balance such that no treatment and discharge of process wastewater to surface water is necessary, although some facilities are equipped to treat and discharge some wastewater during periods of high precipitation.

The average dimensions of the cooling ponds are nearly 60 hectares (145 acres) of surface area and 2.6 meters (8.5 feet) of depth; on a facility-specific basis the surface area ranges from 1 to 260 hectares (2.5 to 640 acres) and depth ranges from 0.3 to 6.7 meters (1 to 21 feet).

12.3 Potential and Documented Danger to Human Health and The Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proven. The Agency's evaluation of the potential dangers posed by phosphogypsum and phosphoric acid process wastewater uses the evidence presented in numerous documented cases of danger to human health and the environment to establish that these wastes can threaten human health and the environment as they are currently managed. Overall conclusions about the hazards associated with phosphogypsum and phosphoric acid process wastewater are provided after these two study factors are discussed.

12.3.1 Risks Associated With Phosphogypsum and Phosphoric Acid Process Wastewater

Any potential danger to human health and the environment from phosphogypsum and phosphoric acid process wastewater depends on the presence of toxic and radioactive constituents in the wastes that may present a hazard and the potential for exposure to these constituents. The Agency has documented cases of dangers posed by these wastes via ground and surface water pathways (see Section 12.3.2), and has previously evaluated potential air pathway dangers from the management of phosphogypsum in stacks. Based on the insights provided by analyses of the hazards posed by phosphogypsum and phosphoric acid wastewater, and information on waste characteristics and management developed for this study, the Agency evaluated the intrinsic hazard of these wastes and the potential for toxic and radioactive constituents from these wastes to pose threats to human health and the environment. This evaluation discusses constituents of potential concern in the wastes and assesses the management practice and environmental setting characteristics that affect the potential for these wastes to pose risks through the ground-water, surface water, and air pathways.

Phosphogypsum Constituents of Potential Concern

EPA identified chemical constituents in phosphogypsum that may present a hazard by collecting data on the composition of this waste and evaluating the intrinsic hazard of the chemical constituents.

Data on Phosphogypsum

EPA's characterization of phosphogypsum and its leachate is based on data from three sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); (2) industry responses to a RCRA §3007 request; and (3) sampling and analysis conducted by EPA's Office of Research and Development (ORD) in 1986. These data provide information on the concentrations of 21 metals, radium-226, thorium-232, uranium-238, gross alpha and beta radiation, a number of other inorganic constituents (i.e., phosphate, phosphorus, fluoride, chloride, sulfate, ammonia, and nitrate), and five organic constituents in total and leach test analyses. Thirteen of the 21 phosphoric acid production facilities are represented by these data.

Concentrations of most (i.e., 21 of 38) constituents in solid samples of phosphogypsum vary considerably among the samples analyzed (i.e., the range of values spans more than three orders of magnitude). Concentration data provided by industry represent a larger number of samples and span a wider range of values than do data from EPA's sampling and analysis efforts. EPA sampling and analysis data for some constituents (i.e., arsenic, selenium, silver, and thallium) do not contribute to the characterization of phosphogypsum because the detection limits used in analyzing these samples are higher than any detected concentrations from analyses of other samples.

Concentrations of most constituents in leach test analyses of phosphogypsum vary considerably less than do concentrations in solid samples (i.e., the ranges of values span less than two orders of magnitude). However, concentrations of chromium, copper, iron, lead, and zinc in EP leach test analyses vary over three or more orders of magnitude. Concentrations from analyses using the EP leach test method are consistently higher than from SPLP method analyses.

Process for Identifying Constituents of Potential Concern

As discussed in Chapter 2, the Agency evaluated the waste composition data summarized above to determine if phosphogypsum contains any chemical constituents that could pose an intrinsic hazard. The Agency performed this evaluation by first comparing the concentration of chemical constituents to screening criteria that reflect the potential for hazards, and then by evaluating the environmental persistence and mobility of constituents that are present at levels above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which constituents in phosphogypsum are released to the environment and migrate to possible exposure points. As a result, this process eliminates from further consideration only those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and air and surface/ground water resources (see Exhibit 2-3). Given the conservative (i.e., protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibits 12-3 and 12-4 present the results of the comparisons for phosphogypsum solid analyses and leach test analyses, respectively, to the screening criteria described above. These exhibits list all constituents for which at least one sample concentration exceeds a relevant screening criterion.

Of the 38 constituents analyzed in total analyses of phosphogypsum, only radium-226, uranium-238, chromium, and arsenic are present at concentrations exceeding the screening criteria (Exhibit 12-3). Maximum concentrations of these constituents are at most seven times the screening criteria. The sample concentrations of the first three of these constituents (i.e., all except arsenic) exceed screening criteria in at least half of the

Exhibit 12-3
Potential Constituents of Concern in Phosphogypsum Solids(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Radium-226	29 / 29	Radiation*(c)	26 / 29	6 / 7
Uranium-238	18 / 18	Radiation*(c)	1 / 18	1 / 3
Chromium	34 / 43	Inhalation*	8 / 43	4 / 8
Arsenic	35 / 43	Ingestion* Inhalation*	34 / 43 29 / 43	2 / 8 1 / 8

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Includes direct radiation from contaminated land and inhalation of radon decay products.

facilities analyzed. None of these constituents, however, exceed the screening criteria by more than a factor of 10.

- Radium-226, and uranium-238 concentrations exceed health-based screening criteria based on multiple radiation pathways. Exceedance of these criteria indicates that phosphogypsum could pose an unacceptable radiation risk if used in an unrestricted manner (for instance, direct radiation doses and doses from the inhalation of radon could be unacceptably high if phosphogypsum is used around homes).
- Chromium and arsenic concentrations exceed the health-based screening criteria for inhalation. This indicates that these constituents could pose a significant cancer risk (i.e., greater than 1×10^{-5}) if phosphogypsum were released to the ambient air as particles.
- Arsenic concentrations exceed the health-based screening criteria for incidental ingestion. This indicates that arsenic may pose a significant incremental lifetime health risk (i.e., greater than 1×10^{-5}) if a small quantity of phosphogypsum or soil contaminated with phosphogypsum is inadvertently ingested on a routine basis (e.g., airborne waste particles may be deposited on crops, or small children playing on abandoned stacks could inadvertently ingest the waste).

EPA sampling and analysis also indicates that levels of gross alpha and beta radiation from phosphogypsum are very high (10 to 100 pCi/g) relative to levels associated with typical soils (approximately 1 pCi/g).

Based on a comparison of leach test concentrations of 29 constituents to surface and ground-water pathways screening criteria (see Exhibit 12-4), 17 constituents were found to be of potential concern for water-based release and exposure. Among these 17 constituents, phosphorus, arsenic, lead, phosphate, manganese, molybdenum, and nickel exceed screening criteria in at least one-half of all facilities analyzed. Twelve constituents exceed the screening criteria by more than a factor of 10, but only chromium was measured in concentrations that exceed the EP toxicity regulatory level. All of these constituents are very persistent in the environment.

Exhibit 12-4
Potential Constituents of Concern in Phosphogypsum Leachate(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Phosphorus	17 / 17	Aquatic Ecological	17 / 17	9 / 9
Arsenic	19 / 28	Human Health*	19 / 28	10 / 11
Lead	14 / 28	Human Health Resource Damage Aquatic Ecological	4 / 28 12 / 28 2 / 28	3 / 11 7 / 11 2 / 11
Phosphate	19 / 19	Aquatic Ecological	19 / 19	9 / 9
Manganese	21 / 22	Resource Damage	9 / 22	6 / 11
Molybdenum	16 / 20	Resource Damage	10 / 22	6 / 10
Nickel	19 / 22	Resource Damage Aquatic Ecological	2 / 22 10 / 20	2 / 11 6 / 11
Iron	20 / 20	Resource Damage Aquatic Ecological	6 / 20 1 / 20	4 / 10 1 / 10
Cadmium	26 / 28	Human Health Resource Damage Aquatic Ecological	4 / 28 7 / 28 7 / 28	3 / 11 4 / 11 4 / 11
Chromium	27 / 28	Human Health Resource Damage Aquatic Ecological	2 / 28 5 / 28 4 / 28	1 / 11 3 / 11 2 / 11
Silver	14 / 26	Aquatic Ecological	6 / 26	3 / 10
Fluoride	17 / 17	Human Health	3 / 17	2 / 9
Zinc	21 / 22	Human Health Resource Damage Aquatic Ecological	1 / 22 1 / 22 2 / 22	1 / 11 1 / 11 2 / 11
Antimony	5 / 22	Human Health	3 / 22	2 / 11
Copper	18 / 22	Human Health Resource Damage Aquatic Ecological	1 / 22 1 / 22 4 / 22	1 / 11 1 / 11 2 / 11
Mercury	3 / 24	Aquatic Ecological	1 / 24	1 / 10
Thallium	1 / 20	Human Health	1 / 20	1 / 10

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. 'Human health' screening criteria noted with an "*" are based on 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

These exceedances of the screening criteria have the following implications:

- Concentrations of arsenic, lead, cadmium, chromium, fluoride, zinc, antimony, copper, and thallium in phosphogypsum leachate exceed screening criteria based on human health risks. This indicates that, if phosphogypsum leachate were diluted less than 10-fold during migration to a drinking water exposure point, long-term chronic ingestion could cause adverse health effects due to the presence of these constituents. The concentration of arsenic in diluted phosphogypsum leachate could pose a cancer risk of greater than $1x10^{-5}$ from long-term drinking water exposures.
- Concentrations of phosphorus, lead, phosphate, nickel, iron, cadmium, chromium, silver, zinc, copper, and mercury in phosphogypsum leachate exceed screening criteria for protection of aquatic life. This means that phosphogypsum leachate could present a threat to aquatic organisms if it migrates (with less than 100-fold dilution) to surface waters.
- Lead, manganese, molybdenum, nickel, iron, cadmium, chromium, zinc, and copper concentrations in phosphogypsum leachate exceed ground and surface water resource damage screening criteria. This indicates that, if released and diluted by a factor of 10 or less, leachate from this waste may contain these constituents in concentrations sufficient to severely restrict the potential future uses of nearby ground and surface water resources.

These exceedances of the screening criteria, by themselves, do not demonstrate that phosphogypsum poses a significant risk, but rather indicate that it may present a hazard. To determine the potential for phosphogypsum to cause significant impacts, EPA proceeded to analyze the actual conditions that exist at the facilities that generate and manage the waste (see the following section on release, transport, and exposure potential).

Process Wastewater Constituents of Potential Concern

Using the same process summarized above for phosphogypsum, EPA identified chemical constituents in phosphoric acid process wastewater that could conceivably pose a risk by collecting data on the composition of this waste, and evaluating the intrinsic hazard of the chemical constituents present in the process wastewater.

Data on Process Wastewater Composition

EPA's characterization of process wastewater and its leachate is based on data from: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW), and (2) industry responses to a RCRA §3007 request. These data provide information on the concentrations of 21 metals, radium-226, uranium-238, gross alpha and gross beta radiation, a number of other inorganic species (i.e., chloride, fluoride, phosphate, nitrate, sulfate, and ammonia), and seven organic compounds in total and leach test analyses. Data on the pH of process wastewater was also collected: at most facilities, the pH is between 1 and 2 standard units, however, two facilities report minimum levels below 1, and 1 facility reports levels between 6.5 and 8 standard units. The waste composition data represent samples collected from 17 of the 21 active phosphoric acid production facilities. As with the concentration data for phosphogypsum, data on the concentrations of most constituents in process wastewater vary over two or three orders of magnitude. Concentrations from leach test analyses of the wastewater vary to a smaller extent.

Concentrations of most (i.e., 22 of 40) constituents in total analyses of process wastewater vary considerably among the samples analyzed (i.e., the range of values spans more than three orders of magnitude). Concentration data provided by industry represent a larger number of samples and span a wider range of values than do data from EPA's sampling and analysis efforts. Concentrations of most constituents in leach test analyses of process wastewater vary considerably less than do concentrations in total analyses (i.e., the ranges of values span two or three orders of magnitude for only five constituents). Because the waste characterization provided by total analyses and leach test analyses are similar, and because the quantity of data is much greater for total analyses, the following analysis of potential constituents of concern in process wastewater is based on the results of total analyses only.

Identified Constituents of Potential Concern

Exhibit 12-5 presents the results of the comparisons for the phosphoric acid process wastewater total analyses to the screening criteria described above. This exhibit lists all constituents for which at least one sample concentration exceeds a relevant screening criterion.

Of the 40 constituents analyzed in process wastewater (and its leachate), levels of arsenic, phosphorus, phosphate, cadmium, chromium, aluminum, gross alpha and beta radiation, radium-226, phenol, iron, manganese, nickel, lead, vanadium, sulfate, copper, boron, molybdenum, antimony, thallium, silver, cobalt, mercury, fluoride, zinc, chloride, beryllium, selenium, and pH exceed the Agency's screening criteria. All of these constituents are metals or other inorganics that do not degrade in the environment.

The first 22 of these 30 constituents are of relatively greater potential concern because their concentrations in samples from at least one-half of all facilities analyzed exceed screening criteria (based on separate evaluations of total liquid and leach test results). Maximum concentrations of phosphorus, phosphate, arsenic, and phenol exceed screening criteria by factors of greater than 1,000 and concentrations of 15 other constituents exceed screening criteria by factors of at least 10. As discussed in Section 12.2, cadmium, chromium, and selenium concentrations are occasionally greater than or equal to the EP toxicity regulatory levels, and the pH is frequently below 2.0, the lower-bound limit for defining a corrosive waste.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Concentrations of arsenic, cadmium, chromium, radium-226, lead, vanadium, copper, antimony, thallium, fluoride, and selenium in process wastewater exceed screening criteria based on human health risks. This indicates that, if process wastewater was diluted 10-fold during migration to a drinking water exposure point, long-term exposures could cause adverse health effects due to the presence of these constituents. Based on long-term drinking water exposures, arsenic concentrations could pose a significant cancer threat (i.e., a lifetime risk of greater than $1x10^{-5}$).

- Concentrations of arsenic, cadmium, chromium, aluminum, gross alpha and beta radiation, radium-226, phenol, iron, manganese, nickel, lead, vanadium, sulfate, copper, boron, molybdenum, cobalt, silver, fluoride, chloride, beryllium, and selenium in process wastewater exceed ground and surface water resource damage screening criteria. This indicates that, if released and diluted less than 10-fold in ground water or less than 100-fold in surface water, phosphoric acid process wastewater may contain these constituents in concentrations sufficient to severely restrict the uses of nearby ground- and surface water resources. In addition, the pH of phosphoric acid plant process wastewater is very low, and water resources may be damaged by the highly acidic nature of this waste.

- Concentrations of arsenic, phosphorus, phosphate, cadmium, chromium, aluminum, iron, nickel, lead, copper, silver, mercury, zinc, and selenium in process wastewater exceed screening criteria based on aquatic life protection. The low pH of the wastewater is also well below the levels that most aquatic life can tolerate. This means that phosphoric acid plant process wastewater may present a threat to aquatic organisms if it migrates (with 100-fold dilution) to surface waters.

These exceedances, by themselves, do not prove that the wastewater poses a significant risk, but rather indicate that it may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for this waste to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the wastewater.

Exhibit 12-5
Potential Constituents of Concern in Phosphoric Acid Process Wastewater (Total)[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Arsenic	77 / 78	Human Health* Resource Damage Aquatic Ecological	76 / 78 37 / 78 21 / 78	15 / 15 8 / 15 5 / 15
Phosphorus	31 / 31	Aquatic Ecological	31 / 31	10 / 10
Phosphate	38 / 38	Aquatic Ecological	38 / 38	9 / 9
Cadmium	73 / 77	Human Health Resource Damage Aquatic Ecological	65 / 77 69 / 77 68 / 77	14 / 15 14 / 15 14 / 15
Chromium	75 / 78	Human Health Resource Damage Aquatic Ecological	26 / 78 65 / 78 44 / 78	8 / 15 14 / 15 9 / 15
Aluminum	58 / 59	Resource Damage Aquatic Ecological	42 / 59 53 / 59	8 / 10 10 / 10
Gross Alpha	46 / 47	Resource Damage	40 / 47	11 / 11
Gross Beta	34 / 47	Resource Damage	30 / 47	9 / 9
Radium-226	86 / 89	Human Health* Resource Damage	26 / 89 14 / 89	9 / 13 5 / 13
Phenol	4 / 5	Resource Damage	4 / 5	3 / 3
Iron	54 / 55	Resource Damage Aquatic Ecological	52 / 55 33 / 55	10 / 10 6 / 10
Manganese	44 / 44	Resource Damage	41 / 44	10 / 10
Nickel	68 / 72	Resource Damage Aquatic Ecological	14 / 72 57 / 72	8 / 14 12 / 14
Lead	64 / 75	Human Health Resource Damage Aquatic Ecological	28 / 75 51 / 75 22 / 75	8 / 15 12 / 15 7 / 15
Vanadium	38 / 41	Human Health Resource Damage	18 / 41 30 / 41	5 / 10 9 / 10
Sulfate	57 / 57	Resource Damage	43 / 57	10 / 11
Copper	69 / 74	Human Health Resource Damage Aquatic Ecological	1 / 74 1 / 74 37 / 74	1 / 14 1 / 14 7 / 14

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on 1x10^{-5} lifetime cancer risk; others are based on noncancer effects.

Exhibit 12-5 (cont'd)
Potential Constituents of Concern in Phosphoric Acid Process Wastewater (Total)[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Boron	2 / 2	Resource Damage	1 / 2	1 / 1
Molybdenum	34 / 39	Resource Damage	27 / 39	10 / 10
Antimony	27 / 70	Human Health	10 / 70	6 / 14
Thallium	18 / 56	Human Health	18 / 56	5 / 13
Cobalt	35 / 41	Resource Damage	7 / 41	3 / 10
Silver	43 / 73	Aquatic Ecological	12 / 73	5 / 14
Mercury	45 / 74	Aquatic Ecological	6 / 74	4 / 14
Fluoride	53 / 53	Human Health Resource Damage	3 / 53 1 / 53	1 / 12 1 / 12
Zinc	77 / 77	Aquatic Ecological	9 / 77	3 / 14
Chloride	26 / 26	Resource Damage	2 / 26	1 / 6
Beryllium	66 / 71	Resource Damage	2 / 71	1 / 14
Selenium	56 / 73	Human Health Resource Damage Aquatic Ecological	1 / 73 2 / 73 2 / 73	1 / 14 1 / 14 1 / 14
pH	68 / 68	Resource Damage	59 / 68	13 / 14

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of phosphogypsum and phosphoric acid plant process wastewater as it was generated and managed at the 21 phosphoric acid facilities in 1988. It does not assess the hazards of off-site use or disposal of these wastes or the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on off-site and projected future conditions.

EPA has identified a variety of documented cases of dangers posed by the release of constituents from these wastes to the environment, and EPA's Office of Air and Radiation (OAR) has studied air pathway risks (from radionuclides) posed by these wastes. Consequently, the Agency has used information on documented and potential damages from these other analyses to support its evaluation of the release, transport, and exposure potential of the current management of these wastes.

Ground-Water Release, Transport, and Exposure Potential

Section 12.3.2 describes documented cases of ground-water contamination at seven phosphoric acid plants located in Central Florida (3), Louisiana (2), North Carolina (1), and Idaho (1). These cases indicate that phosphogypsum and process wastewater constituents have been released to ground water at a number of facilities and, at some sites, have migrated off-site to potable wells in concentrations that are well above hazard criteria. Based on the analysis of the damage case evidence, presented below, EPA concludes that management of phosphogypsum and process wastewater in stacks and ponds can release contaminants to the subsurface, and depending on the hydrogeologic setting and ground-water use patterns, threaten human health via drinking water exposures or render ground-water resources unsuitable for potential use.

In the following paragraphs, EPA presents a region-by-region assessment of the hazards posed by phosphogypsum and process wastewater management. For purposes of this discussion, phosphoric acid plants are grouped into the following eight regions: Central Florida, North Carolina, Louisiana, Idaho, North Florida, Mississippi, Texas, and Wyoming. For each region for which ground-water damages have been documented, the Agency first builds the case that damages attributable to waste management have occurred, then, to the extent necessary, uses environmental setting information to assess the potential hazards (i.e., health risks and resource damage potential) at other facilities in the region. When no damage case information is available for a region, evidence of release potential is used in conjunction with environmental setting information to assess the hazards of potential releases from the plants in these regions.

Central Florida. The Florida Department of Environmental Regulation has initiated enforcement actions in response to ground-water contamination associated with the management of phosphogypsum and process wastewater at all 11 active phosphoric acid production facilities in Central Florida. At three of these facilities (i.e., Central Phosphates, Seminole, and IMC) contamination of the useable intermediate or Floridan aquifers exceeds primary drinking water standards for pH, gross alpha radiation, radium, sodium, total dissolved solids, sulfate, cadmium, chromium, fluoride, and arsenic beyond the permitted zone of discharge.[7] With the exception of sodium and total dissolved solids, all of these constituents were identified as potential constituents of concern in phosphogypsum or process wastewater. At the other eight facilities, contamination exceeding drinking water standards beyond the permitted zone of discharge has been detected only in the surficial aquifer. Two of the three damage cases for Central Florida phosphoric acid production plants presented in Section 12.3.2 (i.e., Central Phosphates and Seminole) discuss contamination of off-site ground water in formations that are used for water supplies. At Central Phosphates, a ground-water contamination plume in the Floridan aquifer extends six acres beyond the facility boundary; contamination of the surficial aquifer covers 28 acres outside the facility boundary. Twelve of 18 potable supply wells down-gradient of the Seminole plant sampled in 1988 contained at least one constituent at a concentration in excess of a drinking water standard. The owner of the phosphoric acid plant paid to have the affected properties connected to a public water supply. These ground-water contamination incidents indicate a high potential for ground-water releases from the phosphoric acid production plants in Central Florida. Except for the Gardinier facility, all operating plants in this area are within 1,000 meters of a public supply well and contamination of the Floridan aquifer at these sites could pose a public health threat via drinking water exposures. As demonstrated by the damage cases and violations of drinking water standards beyond the permitted zone of discharge, contaminants from these wastes can reach the useable aquifer in this area and migrate down-gradient toward potential exposure points.

North Carolina. Section 12.3.2 discusses ground-water contamination resulting from management of process wastewater at the phosphoric acid plant in Aurora, North Carolina. The extent of ground-water contamination at this site is not known with certainty, but fluoride and total dissolved solids concentrations in on-site wells exceed state drinking water standards in the surficial aquifer that is not extensively used and in an intermediate aquifer that is useable, but not developed in the vicinity of the site. No contamination has been detected in a deeper aquifer that serves as the principal water supply in this area. Although off-site migration of contaminants and contamination of the principal water supply aquifer have not been documented, exposures could occur if contaminated drinking water were withdrawn from the surficial aquifer at nearby residences (as close as 100 meters). Even though ground water in the surficial and intermediate aquifers is not currently used as a drinking water source, the documented contamination may render ground water beneath the facility, and possibly down-gradient of the facility, unsuitable for potential future uses.

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[7] The State of Florida allows discharges to ground water within a defined "zone of discharge." The horizontal extent of the zone typically is limited to the property boundary.

Louisiana. Documented cases of ground-water damages from phosphogypsum and process wastewater management at two plants in Louisiana are presented in Section 12.3.2. Data provided in the damage cases indicates that ground water beneath the Geismar facility is contaminated with gross alpha radiation at concentrations more than six times the federal primary drinking water standard. In addition, the Louisiana Department of Environmental Quality concluded in 1986 that "contamination of the shallow ground water [at Donaldsonville], although by constituents which are not of great concern, poses a threat to drinking water."[8] Current human health threats via drinking water at the Donaldsonville and Geismar facilities are unlikely because there are no private residences or public wells that derive drinking water supplies within 1,600 meters (1 mile) down-gradient of these facilities. However, ground-water releases are also likely at the third active Louisiana plant (Uncle Sam), and potential exposures to contaminated ground water could occur at a residence located 180 meters down-gradient from this facility.

Idaho. One of the two phosphoric acid plants in Idaho is discussed in a damage case in Section 12.3.2. Although this damage case does not provide conclusive evidence of long-term ground-water contamination from releases of phosphogypsum and process wastewater, data presented indicate that a few constituents of concern for these wastes (e.g., selenium, manganese, sulfate, and phosphate) may be contaminating ground water down-gradient of the Caribou facility. Because of relatively high levels of background contamination, a recent geophysical survey at Caribou did not delineate a ground-water contamination plume originating at the plant. Nevertheless, selenium concentrations exceed federal secondary drinking water standards at on-site and down-gradient off-site production wells, and phosphate concentrations at a down-gradient off-site production well exceed background levels by a factor of 170. Both of these constituents are found in process wastewater, and a recent EPA site inspection report concludes that the ground-water monitoring data "suggest that some leakage from the [process wastewater] cooling pond may be occurring presently."[9] In addition to this evidence of continuing contamination of the useable aquifer, the Caribou damage case discusses a spill of process wastewater, resulting from a dike failure, that contaminated off-site ground water with cadmium (at a concentration more than four times the federal drinking water standard), phosphate, and fluoride. Consequently, EPA concludes that typical management of phosphogypsum and process wastewater in Idaho may allow the continuous seepage of contaminants to ground water, and mismanagement (i.e., spills) of process wastewater has caused ground-water contamination. Any ground-water contamination that does occur as a result of waste management at the two Idaho facilities could pose human health threats at residences located 240 and 850 meters down-gradient of the Caribou and Pocatello plants, respectively.

North Florida and Mississippi. Although not demonstrated in the documented damage cases, ground-water contamination potential also appears to be relatively high at the plants in North Florida and Mississippi. As with the Central Florida facilities, the White Springs facility in North Florida is in karst terrane (characterized by sinkholes and underground cavities developed by the dissolution of carbonate rock such as limestone) which creates the potential for contaminant transport with limited dilution. Releases at this plant could result in exposures at a residence located 180 meters down-gradient. Ground-water contamination potential appears high at the Pascagoula plant in Mississippi because ground water occurs at a depth of only 1.5 meters in this area. Human populations are not likely to be exposed to potential ground-water contaminants at this facility, however, because currently there are no residences or public supply wells within 1,600 meters down-gradient from the facility.

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[8] Louisiana Department of Environmental Quality. 1986. Letter from George H. Cramer, II, Administrator to Susan Stewart, Agrico Manager Energy and Environmental Control, Re: Hydrogeologic Assessment, Final Report GD-093-0791.

[9] EPA Region 10. 1988. Site Inspection Report to Nu-West Industries. Conda Plant, Caribou, Idaho. TDD F10-8702-08.

Texas and Wyoming. The potential for ground-water pathway risks at the Texas and Wyoming facilities is relatively low. Releases from the management units at the plant in Pasadena, Texas are limited to some extent because the stack at this facility is lined with recompacted local clay, and exposures to existing populations are unlikely because there is no residence or public supply well within 1,600 meters down-gradient from the facility. Similarly, the facility in Rock Springs, Wyoming poses a relatively low risk because its stack has a synthetic liner and the nearest down-gradient residence is quite distant (greater than 1,600 meters).

Surface Water Release, Transport, and Exposure Potential

The potential for the release of contaminants from phosphogypsum stacks and process wastewater ponds to surface water is also demonstrated by the damage cases presented in Section 12.3.2. These cases indicate that phosphogypsum and process wastewater management at plants in Central Florida, North Carolina, and Louisiana has resulted in the release of waste constituents to surface waters. Based on the analysis of the damage case evidence, it is clear that management of phosphogypsum and process wastewater in stacks and ponds can, and does, release contaminants to nearby surface waters. Depending on the distance to surface waters, the hydrogeologic setting, and surface water use patterns, EPA concludes that there is a potential for these released contaminants to migrate off-site and threaten human health via drinking water exposures, threaten aquatic life, or render surface water resources unsuitable for potential consumptive uses.

In the following paragraphs, EPA presents a region-by-region assessment of the hazards to surface water quality posed by phosphogypsum and process wastewater management. For each region for which surface water releases have been documented, the Agency first builds the case that releases from waste management units have occurred in the past and are typical of current practices, then uses environmental setting information to assess the potential hazards (i.e., health risks, risk to aquatic organisms, and resource damage potential) at other facilities in the region. When no damage case information is available for a region, evidence of release potential is used in conjunction with environmental setting information to assess the hazards of potential releases from the plants in these regions.

Central Florida. The damage cases presented in Section 12.3.2 indicate that unpermitted discharges of process wastewater and/or phosphogypsum stack seepage to surface waters have occurred at the Gardinier and Seminole plants in Central Florida. At the Gardinier facility, a number of releases from 1984 to 1988 have been documented. Releases to surface water from solid waste management at this plant arise from the discharge of untreated stack seepage from a drain system that is designed to intercept and collect leachate and effluent flowing laterally away from the stack. As indicated in the damage cases, fluorides, phosphorus, and radioactive substances are present at concentrations of concern in the effluent from this drain system. In addition, these unpermitted discharges had a pH of 1.5 to 2.2. In 1988, county and state inspectors discovered damaged vegetation on the shoreline of Hillsborough Bay along the west side of the gypsum stack where an unpermitted discharge was occurring. The affected area -- approximately one-half acre of saltwater marshes and wax myrtle -- had turned a brownish color,[10] presumably as a result of the discharge of untreated stack seepage. At the Seminole facility, surface water contamination has occurred via an unpermitted discharge to Bear Branch. Similar releases, or releases of contaminated ground-water discharging to surface water, could also occur at the eight other facilities in this area that are located near surface waters. At two of these facilities (i.e., Central Phosphates and IMC), the nearby river is used as a source of drinking water downstream of the facility and releases to these rivers could pose a human health threat via drinking water exposures. Of the 11 active Central Florida plants, only Royster/Mulberry is not within 1,000 meters of surface water and is unlikely to pose a threat to surface water resources.

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[10] Hillsborough County Environmental Protection Commission. October 6, 1988. Memorandum from Roger Stewart, Director, to Pam Iorio, Commissioner.

North Carolina. As at the Gardinier plant, unpermitted discharges of stack drainage and process wastewater from the plant in Aurora, North Carolina are also associated with failure of the drain system designed to collect seepage at the foot of the gypsum stacks. In two separate incidents in 1980 and one in 1987, concentrations of fluoride and phosphorus released from the plant exceeded permit limits as a result of drainage ditch and dike failure and drain overflow. In the 1987 episode, the pH of a freshwater canal was below 6.0 for two hours and 18 dead fish were discovered in the week following the release. Based on this evidence, the Agency concludes that episodic releases from the phosphogypsum stack and ponds at this facility were not adequately controlled by run-on/run-off controls and collection of stack seepage. In addition, contaminants released to ground water may discharge to the Pamlico River and to the creeks in the vicinity of the site where they may endanger aquatic life.

Louisiana. Two documented cases of surface water damages from phosphogypsum and process wastewater management in Louisiana are presented in Section 12.3.2. At both the Donaldsonville and Geismar plants, releases occurred as a result of the emergency discharge of untreated water from gypsum stacks and ponds to surface waters. As noted in the damage cases, the facility operators claimed that these discharges were necessitated by excess precipitation that threatened to cause stack failures. Emergency discharges are permitted at facilities on the lower Mississippi during periods of excess precipitation. As discussed above, ground-water contamination potential is also significant at the three facilities in Louisiana, and ground water discharging to surface waters may provide another means of contaminant release. The threats posed by releases to surface waters in Louisiana may be limited somewhat by the large flow of the Mississippi River. Because the Mississippi River is not used as a source of drinking water directly downstream of the three phosphoric plants, releases from these plants do not pose any current human health threats.

Based on the evidence presented above, EPA concludes that constituents of phosphogypsum and process wastewater that are managed near surface water bodies are likely to be released to nearby surface waters as a result of stack failures, drain failure, and possibly ground-water seepage. The facilities in Pasadena, Texas; Pascagoula, Mississippi; and White Springs, Florida (north) are located close to surface waters and receive relatively large quantities of precipitation. Consequently, these plants may present a hazard to surface water similar to that of the Louisiana and Central Florida facilities. The surface water contamination potential at the plant in Pocatello, Idaho is somewhat lower because the small amount of precipitation limits ground-water recharge and the possibility of stack failure due to excess precipitation, but contamination of the Portneuf River (located only 240 meters away) may occur. Surface water contamination is unlikely at the plants in Rock Springs, Wyoming and Caribou, Idaho because of the relatively small amounts of annual precipitation (i.e., 20 to 35 cm/year) and the large distances to the nearest surface water (370 to 2,600 meters).

Air Release, Transport, and Exposure Potential

Air pathway hazards associated with phosphogypsum and process wastewater relate primarily to the emission of radon gas from the radioactive decay of radium found in these wastes and the emission of particulate matter resulting from the disturbance of the phosphogypsum stack surface.

In support of a rulemaking on national emission standards for radionuclides, EPA's Office of Air and Radiation (OAR) has assessed the risks of radon emissions from phosphogypsum stacks.[11] In this risk assessment, OAR estimates that the lifetime cancer risk to the maximally exposed individual (MEI) caused by the inhalation of radon in the vicinity of a phosphogypsum stack is $9x10^{-5}$. The MEI lifetime cancer risk from radon inhalation is greater than or equal to $1x10^{-5}$ at 17 of the 21 active phosphoric acid facilities. Only the plants in Pascagoula, Mississippi; Aurora, North Carolina; Rock Springs, Wyoming; and White Springs, Florida have an estimated MEI lifetime cancer risk from radon inhalation of less than $1x10^{-5}$.

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[11] U.S. EPA, 1989, Risk Assessments: Environmental Impact Statement for NESHAPS Radionuclides, Volume 2 (Background Information Document), Office of Radiation Programs.

Because phosphogypsum forms a crust on inactive areas of the stack as it dries, and because the active areas of the stack are moist, the emission of particulate matter by wind erosion is not thought to be a significant release mechanism.[12] Physical disturbance of dried phosphogypsum (e.g., by vehicles driving over the stacks), however, may be an important particle release mechanism. The OAR risk assessment estimated that the lifetime cancer risks from radionuclides in particle emissions from stacks range from $8x10^{-8}$ to $2x10^{-6}$. Based on these risk estimates, the OAR assessment concludes that the risk from inhaling radon emitted from phosphogypsum stacks is approximately two orders of magnitude greater than the cancer risk posed by the inhalation of fugitive dust from phosphogypsum stacks.

The OAR study did not investigate the cancer risk posed by other toxic constituents (i.e., arsenic and chromium) in phosphogypsum via particle inhalation. To supplement OAR's radiological assessment, EPA performed a screening level analysis of the risks posed by arsenic and chromium blown from phosphogypsum stacks. Using typical concentrations of arsenic and chromium in phosphogypsum, EPA calculated a lifetime cancer risk of $7x10^{-7}$ from exposure to these constituents in windblown phosphogypsum.[13] This analysis shows that the risk posed by arsenic and chromium in inhaled phosphogypsum particles is on the order of 35 percent of the risk posed by radionuclides in inhaled particles.

Based on the these findings, the Agency concludes that phosphogypsum stacks pose a considerable air pathway cancer risk primarily as a result of radon emissions from the stacks. By summing the risk estimates for radon inhalation, radionuclides in phosphogypsum particles, and arsenic and chromium in particles, EPA estimates a total air pathway lifetime MEI cancer risk of approximately $9x10^{-5}$ from exposure to phosphogypsum constituents. This risk is primarily from inhalation of radon emitted from stacks ($9x10^{-5}$) with minor contributions from the inhalation of phosphogypsum particles containing radionuclides ($2x10^{-6}$) and arsenic and chromium ($7x10^{-7}$). Based on the OAR estimates of risk from radon emitted from the stacks, the following plants appear to pose the greatest air pathway risks: Pasadena, Texas; Royster/Palmetto; Uncle Sam, Louisiana; Seminole; Central Phosphate; and Caribou, Idaho. As mentioned above, the stacks at Pascagoula, Mississippi; Aurora, North Carolina; Rock Springs, Wyoming; and White Springs, Florida pose lower MEI lifetime cancer risk (i.e., $< 1x10^{-5}$).

Proximity to Sensitive Environments

Eighteen of the 21 active U.S. phosphoric acid plants are located in or near environments that are vulnerable to contaminant release or that have high resource value. In particular:

- The Seminole facility reported in its response to the National Survey on Solid Wastes from Mineral Processing Facilities that it is located in an endangered species habitat.
- The Royster/Palmetto and Pascagoula facilities are located within 6.5 and 7.8 miles, respectively, of the critical habitat of an endangered species. The two endangered species are the Florida Manatee and the Mississippi Sandhill Crane. Because of the

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[12] Ibid. p. 13-2.

[13] This risk estimate is based on a comparison of the dust inhalation risks posed by (1) median arsenic and chromium concentrations as determined by EPA's data base developed for this study and (2) average concentrations of radium-226, uranium-234, uranium-238, thorium-230, polonium-210, and lead-210 presented in the OAR analysis. To calculate the relative risks posed by these constituent concentrations, EPA assumed an exposure point concentration of windblown phosphogypsum in air, and applied standard cancer slope factors and exposure assumptions, such as those used in developing the screening criteria (see Section 2.2.2), to estimate the relative contributions of carcinogenic metals and radionuclides to the inhalation risks posed by airborne phosphosypsum.

relatively large distance to these protected areas, the potential for impacts on the species or their critical habitat is quite low.

- Eight plants (i.e., Geismar, CF Chemicals, Gardinier, Pocatello, Pasadena, Pascagoula, Seminole, and Aurora) are located in 100-year floodplains. Management of wastes in floodplains creates the potential for large, episodic releases caused by flood events. (The effectiveness of flood control structures at these plants is not known.)
- The Gardinier, Pascagoula, and Aurora plants are located in a wetland (defined here to include swamps, marshes, bogs, and other similar areas). The Agrico/Mulberry, Geismar, Central Phosphates, CF Chemicals, Conserv, Royster/Palmetto, Farmland, Fort Meade, IMC, Caribou, White Springs, Royster/Mulberry, and Seminole plants are located within one mile of a wetland. Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural water, provide flood and storm damage protection, and afford a number of other benefits. Although the location of wetlands relative to potential contaminant sources is unknown, if contaminants released to surface water and ground water migrate to wetlands, the water quality degradation may adversely affect the wetland.
- The Pocatello facility is located in a fault zone. Wastes managed in a fault zone may be subject to episodic releases due to earthquake-induced failure of containment systems or berms.
- The Central Phosphates and Royster/Palmetto facilities are located in an area of karst terrain characterized by sinkholes and underground cavities developed by the dissolution of carbonate rock. Solution cavities that may exist in the bedrock at this site could permit any ground-water contamination originating from the wastes to migrate in a largely unattenuated and undiluted fashion.

Risk Modeling

Based upon the evaluation of intrinsic hazard and the descriptive analysis of factors that influence risk presented above, EPA has concluded that the potential for phosphogypsum and process wastewater from phosphoric acid production to impose risk to human health or the environment is significant, if managed according to current practice. As discussed above,

- Phosphogypsum and phosphoric acid process wastewater contain a number of constituents at concentrations that exceed conservative screening criteria, phosphogypsum occasionally contains chromium concentrations in excess of the EP toxicity regulatory level, and process wastewater regularly exhibits the RCRA hazardous waste criterion for corrosivity (i.e., pH below 2.0) and exceeds EP regulatory levels for cadmium, chromium, and selenium.
- Ground-water contamination from phosphogypsum stacks and process wastewater ponds has occurred or is likely at almost all plants, and, at some sites, contamination has reached off-site wells at levels above drinking water standards.
- Episodic and continuous releases of pond and phosphogypsum stack waters to surface water occur at a number of plants, and aquatic organisms have been adversely affected by these releases.
- Radon emissions from phosphogypsum stacks and windblown phosphogypsum particles are estimated to present a lifetime cancer risk to maximally exposed individuals of almost $1x10^{-4}$.

Because of the weight of the empirical and analytical evidence summarized above, the Agency did not conduct a quantitative risk modeling exercise addressing these wastes. Section 12.3.3 provides a more detailed discussion of the Agency's conclusion that current management of phosphogypsum and phosphoric acid process wastewater poses a significant hazard.

12.3.2 Damage Cases

EPA conducted waste management case studies to assess the impacts of phosphogypsum and process wastewater management practices on human health and the environment. This review included 21 active and eight inactive phosphoric acid facilities. The inactive facilities are: Agrico, Hahnville, LA; Agrico, Fort Madison, IA; Albright & Wilson, Fernald, OH; JR Simplot, Helm, CA; Mobil Mining & Minerals, De Pue, IL; U.S. Agri-Chemicals Corp., Bartow, FL; Waterway Terminals, Helena, AR; and MS-Chemical located in Pascagoula, Mississippi. Documented damages attributable to management of phosphogypsum or process wastewater have been documented at more than ten facilities. Selected facilities are discussed in detail below.

Several factors play an important role in influencing the effectiveness of typical phosphogypsum and process wastewater management practices. Among these are water balance and soil stability. In Florida, for example, phosphogypsum dewatering and reduction of wastewater volumes are made possible due to the climate, specifically the relative amounts of precipitation and evaporation, in this region. In other areas, however, such as Louisiana, a net precipitation surplus necessitates a system dependent on planned discharges to surface waters. Soil stability appears to be much greater in Florida as well, where gypsum may be stacked to heights up to 60 meters (200 feet). In Louisiana, gypsum piles over 12 meters in height are generally considered unstable. In light of these differences, the case studies presented in this section are grouped by state.

Idaho

Nu-West Industries-Conda, Soda Springs, Idaho

The Nu-West plant is located approximately five miles north of Soda Springs, Idaho, near the abandoned mining town of Conda. The site covers approximately 650 hectares (1,600 acres). With the exception of a period from 1985 to 1987, the plant has been in operation since 1964.

Currently, Nu-West formulates and markets phosphate-based chemicals and fertilizers. The phosphogypsum waste is a by-product of the digester system, which produces ortho-phosphoric acid (P_2O_5) from phosphate ore. Gypsum is slurried with process water and pumped to two storage ponds on top of the gypsum stacks, which have been in use since 1964 and presently cover approximately 240 to 280 hectares (600 to 700 acres). The gypsum ponds are unlined; the stacks are about 46 meters (150 feet) above the natural ground surface. Drainage systems decant slurry water off the top of the higher ponds into ponds at lower elevations.

During March 1976, a dike surrounding the Nu-West cooling pond failed and released 400 acre feet of wastewater into the surrounding area. The water spread out and ponded on an estimated 20 to 40 hectares (50 to 100 acres) of farm land. The water then migrated via a natural drainage path, forming a small river that extended four miles to the south. Wastewater reportedly infiltrated into local soil and underlying bedrock along its overland migration path, but never entered a natural surface water body.

While the Idaho Division of Environment determined that dilution during spring run-off reduced surface concentrations of contaminants to within acceptable limits, the Caribou County Health Department recorded significant increases in ground-water concentrations of phosphate, cadmium, and fluoride immediately following the spill. Samples from a J.R. Simplot Company (Conda Operation) production well No. 10, located down-gradient from the Nu-West facility, show that before the spill occurred, levels of phosphate in the ground water averaged 100 mg/L, and rose to 1,458 mg/L after the spill. Levels of cadmium in the ground water averaged 0.01 mg/L before the spill and 0.239 mg/L after the spill, and levels of fluoride averaged 5 mg/L before, and 39 mg/L after, the spill, respectively.[14]

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[14] EPA Region 10. 1988. Site Inspection Report to Nu-West Industries Conda Plant, Caribou, Idaho. TDD F10-8702-08. March, 1988.

In 1987, EPA Region X conducted a file review and site inspection of Nu-West. This inspection included ground-water sampling, aqueous and solid sampling from the waste ponds, and a geophysical survey. A total of six ground-water samples were collected: two from on-site industrial production wells (MF well, P.W. No. 1); two off-site industrial production wells (Simplot No. 11, Simplot No. 10); and, two domestic wells in the site area. Results of the Nu-West site inspection were published in a site inspection report in March, 1988. Selenium exceeded Federal Primary Drinking Water Standards in all of the production well samples. Manganese and sulfate exceeded Federal Secondary Drinking Water Standards in Simplot Well No. 10. Phosphate was detected at 8.2 mg/L in Simplot Well No. 10, a level approximately 30 times greater than that found in the MF well and 170 times greater than that found in the background well (Simplot Well No. 11). A total of eleven target compound list (TCL) inorganic elements were detected in at least one of the domestic well samples; however, none of the sample concentrations exceeded Federal Primary or Secondary Drinking Water Standards.[15]

The geophysical survey results indicated that there was no significant difference between the background and on-site values obtained from the survey. However, as stated in the EPA Site Inspection Report: "There are seven registered domestic wells within a three mile radius of the Nu-West site, serving an estimated 27 people. Total depths of these wells range between 90 feet to 245 feet below ground surface. Eleven registered industrial production wells exist on and near the Nu-West site, one of which provides drinking water for approximately 45 J.R. Simplot employees in Conda (Simplot #11). At the time of the [EPA] inspection, Nu-West employees consumed bottled water due to poor water quality of the only well in use at the site (MF well)."[16]

The EPA Site Inspection Report concludes by stating: "Levels of TCL inorganic elements and anions detected in the groundwater samples during the [EPA] site investigation were similar to those obtained by the Caribou County Health Department during non-spill event time periods. However, the levels detected during the [EPA] site investigation should not be considered indicative of stable long-term groundwater quality conditions at the site. [Data show] that significant increases in groundwater contaminant concentrations have occurred as a result of a past spill at the Nu-West facility. Although survey results are inconclusive, the data suggest that some leakage from the cooling pond may be occurring presently. If leakage from the cooling pond increases as a result of pond aging or increased water circulation, a contaminant plume may develop and migrate to the south-southwest."[17]

Florida

Gardinier, Inc., in East Tampa, Florida

Gardinier, Inc.'s East Tampa Chemical Plant Complex encompasses about 2,600 acres of land and is located in west-central Hillsborough County, Florida. The facility is located at the mouth of the Alafia River adjacent to Hillsborough Bay. The plant began its operations in 1924 and has been expanded several times by various owners. In 1973, Gardinier, Inc. took over the entire operation. Gardinier, Inc. is owned by Cargill, Inc. of Minneapolis, Minnesota. Operations currently include production of phosphoric acid and phosphate and other fertilizers.[18,19]

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[15] Ibid.

[16] EPA Region 10. 1988. Site Inspection Report to Nu-West Industries Conda Plant, Caribou, Idaho. TDD F10-8702-08. March, 1988.

[17] Ibid.

[18] Ardaman & Associates, Inc. September 23, 1983. Groundwater Monitoring Plan for East Tampa Chemical Plant Complex, Hillsborough County, Florida.

[19] Ibid.

Gardinier's on-site waste management units include two process water ponds (Nos. 1 and 2) and a gypsum stack. Process Water Pond No. 1 is an unlined pond that occupies 13 hectares (32 acres) and is 2 meters (6 feet deep); Process Pond No. 2 occupies 80 hectares and is 2.1 meters deep. The gypsum stack, which as of December 31, 1988 contained about 58 cubic meters (76 million cubic yards) of material, occupies an area of 150 hectares and is 61 meters high. The ponds on top of the gypsum stack occupy 16 hectares and are 2 meters deep. The typical pH of the liquid in the gypsum stack ponds is 1.8.[20]

Phosphogypsum is piped to the gypsum stack as a slurry mixture (approximately 30 percent solids). The gypsum settles from the slurry and the liquid is decanted for reuse in the manufacturing process. Water which seeps through the stack is collected in a perimeter drain that is buried at the toe of the stack. The drain carries the seepage water to a sump in the northeast corner of the gypsum stack where it is pumped to an evaporation pond located on part of the gypsum stack. Surface water run-off from the exterior slopes of the stack is discharged into Hillsborough Bay.[21]

Records at the Hillsborough County Environmental Protection Commission (HCEPC) cite environmental incidents at the Gardinier facility as far back as November 21, 1973, when HCEPC investigated a citizen's complaint and discovered 210 dead crabs in traps placed near the facility's northwest outfall. The pH of the outfall water was 2.9.[22,23]

Water quality violations attributable to Gardinier resulted in the following administrative actions: a Consent Order negotiated between the HCEPC and Gardinier on August 22, 1977; a Citation to Cease Violation and Order to Correct from HCPEC on November 8, 1984; a Warning Notice from the State of Florida Department of Environmental Regulation (FDER) on April 9, 1987; a Citation to Cease and Notice to Correct Violation from the HCEPC on May 26, 1988; and, a Warning Notice from FDER on October 18, 1988. These administrative actions were issued to Gardinier following unpermitted discharges from either the gypsum stack or the cooling water ponds.

The November 8, 1984 citation was issued for an untreated effluent discharge which occurred on October 8, 1984. The citation notes that "toe-drain effluent contains several thousand milligrams per liter of fluorides and phosphorus and up to 150 pico-curries per liter of radioactive substances. Also, its pH can be as low as 1.5 standard units."[24] A sample of the discharge on March 30, 1987, which resulted in the April 9, 1987 warning notice, shows that the pH was 1.9, total phosphorus was 6,740 mg/L and dissolved fluorides was 4,375 mg/L.[25] HCEPC analyzed a sample of the discharge which resulted in the October 18, 1988 warning notice and reported the following results: pH, 2.2; total phosphorus, >4,418 mg/L; and fluoride, 1,690 mg/L.[26]

The May 26, 1988 citation from HCEPC states that "available agency records indicate a considerable history of incidents of discharge resulting in exceedances of environmental standards and contamination of the air and waters of Hillsborough County. Enforcement in each case required remedial actions intended to correct the effects of the discharge where appropriate, as well as design and maintenance measures to prevent reoccurrence of the same or like incident. Despite all efforts, such incidents continue to occur."[27]

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[20] Gardinier, Inc. March 29, 1989. National Survey of Solid Wastes from Mineral Processing Facilities.

[21] Ardaman & Associates, Inc. September 23, 1983. Groundwater Monitoring Plan for East Tampa Chemical Plant Complex, Hillsborough County, Florida.

[22] Hillsborough County Environmental Protection Commission. May 6, 1988. Gardinier History.

[23] Hillsborough County Environmental Protection Commission. November 26, 1973. Interoffice Memo from Robert M. Powell to Richard Wilkins.

[24] Hillsborough County Environmental Protection Commission. November 8, 1984. Citation to Cease Violation and Order to Correct issued to Gardinier, Inc.

[25] Hillsborough County Environmental Protection Commission. March 31, 1987. Notice of Alleged Violation issued to Gardinier, Inc.

[26] Florida Department of Environmental Regulation. October 18, 1988. Warning Notice No. WN88-0001IW29SWD issued to Gardinier, Inc.

HCEPC records also include a Gardinier Air Complaints Summary which lists 78 citizen complaints about the facility from December 6, 1983 to May 10, 1988. The complaints were made about noxious odors, fumes, smoke, dust or mist from the facility. One of the complaints clearly identifies the gypsum stack as the source; the relationship of the other complaints to gypsum and water management systems at the facility cannot be determined from the available documentation. HCEPC responded to most of these complaints with a phone call or site visit. At least three of the site visits resulted in HCEPC issuing a warning notice to the facility.[28]

Since 1985, Gardinier has monitored ambient air quality for radon and fluoride. In 1985, Gardinier reported its average radon-222 flux from the gypsum pile to be 21.6 pCi/square meter-second (the recently promulgated NESHAP specifies a limit of 20 pCi/m^2-sec). Ambient fluoride was 0.43 ppb, with a maximum reading of 1.2 ppb.[29] Nonetheless, Gardinier reported that no National Ambient Air Quality Standards or National Emissions Standards for Hazardous Air Pollutants were exceeded during 1988.[30]

In addition to the impacts to surface water, biota, and air noted above, ground water at the facility has been affected by facility operations. Ground-water quality has been monitored quarterly at the facility for several years. Since January 1, 1984, standards for the following drinking water parameters were exceeded in wells located both up-gradient and down-gradient of the facility's special waste management units: chromium, radium-226 and radium-228, gross alpha, chloride, iron, manganese, pH, and total dissolved solids.[31] Examination of data for the period 1987 through early 1989 indicates that several on-site wells in the shallow aquifer routinely exceeded the gross alpha primary drinking water standard by a factor of between 2 and 4; exceedances in the intermediate aquifer were also common, although less frequent and of lesser magnitude.

Central Phosphates, Plant City, Florida

The Central Phosphates, Inc. (CPI) Plant City Chemical Complex is located approximately 16 km (10 miles) north of Plant City. The facility occupies approximately 616 hectares (1,520 acres) of land.[32] The site is underlain by a surficial aquifer and the Floridan aquifer. The surficial aquifer ranges in depth from .3 to 15 meters (one to 50 feet) and is recharged by local rainfall.[33] In the Floridan aquifer, the uppermost useable aquifer at the site, wells are generally cased to depths greater than 200 feet.[34] The principal uses of the water in the uppermost useable aquifers underlying the site are rural domestic, agricultural, and commercial/ industrial.[35]

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[27] Hillsborough County Environmental Protection Commission. May 26, 1988. Case No. 6169 WP. Citation to Cease and Notice to Correct Violation issued to Gardinier, Inc.

[28] Hillsborough County Environmental Protection Commission. Undated. Gardinier Air Complaints Summary.

[29] Gardinier, Inc. September 25, 1985. First Annual Report submitted to the Hillsborough County Administrator pursuant to Development Order 80-713.

[30] Gardinier, Inc. March 29, 1989. "National Survey of Solid Wastes from Mineral Processing Facilities."

[31] Ibid.

[32] Ardaman & Associates, Inc., April 2, 1987, Geotechnical Evaluation and Design Recommendations for Proposed Gypsum Stack Expansion, Plant City Chemical Complex, Hillsborough County, Florida (part).

[33] Central Phosphates, Inc., March 29, 1989, "National Survey on Solid Wastes from Mineral Processing Facilities."

[34] Ardaman & Associates, Inc., August 9, 1988, Contamination Assessment Report, Central Phosphates, Inc., Plant City Phosphate Complex, Hillsborough County, Florida.

[35] Central Phosphates, Inc., March 29, 1989, "National Survey on Solid Wastes from Mineral Processing Facilities."

The CPI plant began operation in December 1965; principal products include phosphate fertilizer, sulfuric acid, and ammonia.[36] Phosphogypsum generated during the production of phosphoric acid is disposed onsite at the company's 170 hectare (410-acre) phosphogypsum stack. A 50 hectare unlined process water cooling pond completely surrounds the gypsum stack. The depth of the cooling pond is 2.4 meters (8 feet). As of December 31, 1988, the unlined gypsum stack was 111 feet high and contained approximately 70,000,000 tons of material. The top of the gypsum stack presently contains 8 ponding areas occupying a total area of approximately 105 hectares. Two designated areas on top of the stack, located in the middle, are used for disposal of non-hazardous waste materials, such as construction and demolition debris and non-hazardous chemicals.[37]

Activities at the Central Phosphates site have resulted in ground-water contamination in the surficial and upper Floridan aquifers. To date, it has been determined that the surficial aquifer and, to an undetermined extent, the Floridan aquifer have increased levels of fluoride, sodium, gross alpha radiation, heavy metals, sulfate, total dissolved solids, and nutrient compounds in excess of applicable guidance concentrations and/or state and federal drinking water standards. Contaminated ground water, primarily in the surficial aquifer, has migrated off-site under approximately 11 hectares (27.5 acres) of the Cone Ranch property, located south of the CPI facility.[38,39]

Quarterly ground-water sampling began at the Central Phosphates facility in April 1985. Based on the results of sampling from these wells in the second quarter of 1985, a warning notice was issued to the facility by the Florida Department of Environmental Regulation (DER) for violation of the primary drinking water regulations. Maximum contamination levels for sodium and chromium were exceeded in a down-gradient well in the Floridan aquifer and for sodium, chromium, and fluoride in a down-gradient well in the surficial aquifer.[40]

In June 1987 the West Coast Water Supply Authority provided DER with preliminary data from laboratory analysis of ground-water samples collected from the Cone Ranch property which indicated degradation of both the surficial and the upper Floridan aquifers.[41]

The final report on ground-water investigations conducted at Cone Ranch during May and June 1987, prepared by consultants to the West Coast Regional Water Supply Authority, identifies two areas of contamination on the Cone Ranch property. The report concludes that contamination in one area (designated Area A) was caused by a dike failure and resultant spill of process water from the Central Phosphates facility in 1969 and that contamination in another area (Area B) was caused by seepage of contaminated water from the recirculation pond located immediately north of the spill area.[42]

A consent order addressing the ground-water contamination problems at the site was drafted by DER during July of 1987 and signed by DER and Central Phosphates, Inc. on September 29, 1987. The consent order documents violations of primary and secondary drinking water standards for chromium, sodium, fluoride, gross alpha radiation, lead, and cadmium from a down-gradient well in the surficial aquifer. These violations occurred from May 6, 1985 through April 27, 1987; maximum values listed in the consent order for each contaminant are as follows: chromium, 0.075 mg/L; sodium, 1700 mg/L; fluoride, 6 mg/L; gross alpha, 29 pCi/L; lead, 0.11 mg/L; and, cadmium, 0.022 mg/L. The consent order required Central Phosphates, Inc. to implement corrective measures and ground-water remediation at the site.[43]

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[36] Ardaman & Associates, Inc., September 21, 1987, Quality Assurance Project Plan, Central Phosphates, Inc., Plant City Phosphate Complex (part).

[37] Central Phosphates, Inc., March 29, 1989, "National Survey on Solid Wastes from Mineral Processing Facilities."

[38] West Coast Regional Water Supply Authority. May 11, 1989. Letter from M. G. Korosy, Hydrologic Services Manager, to M. Troyer, ICF, Inc.

[39] Ardaman & Associates, Inc., August 9, 1988, Contamination Assessment Report, Central Phosphates, Inc., Plant City Phosphate Complex, Hillsborough County, Florida.

[40] State of Florida, Department of Environmental Regulation, Warning Notice No. 29-85-07-182, July 17, 1985.

[41] Case Chronology for Central Phosphates, Inc., undated, Florida Department of Environmental Regulation enforcement files.

[42] Leggette, Brashears & Graham, Inc., July 15, 1987, West Coast Regional Water Supply Authority Hydrologic and Water Quality Site Investigation at Cone Ranch, Hillsborough County, Florida.

The Joint Water Quality/RCRA Overview Committee of the Florida Phosphate Council has recorded quarterly sampling data from the Central Phosphates, Inc. site from April 24, 1985 through January 18, 1989 for DER Well Nos. 1 through 6, as well as data from sampling in April 1988 for miscellaneous other wells located both on and off CPI property. These data show consistent exceedances of water quality standards in the down-gradient surficial aquifer for pH, iron, fluoride, manganese, total dissolved solids, and sulfate. Water quality standards for iron and total dissolved solids were consistently exceeded in the down-gradient upper Floridan aquifer.[44]

The Contamination Assessment Report (CAR) for the CPI facility, prepared pursuant to the Consent Order, concurs with the assessment made by the West Coast Regional Water Quality Authority in its definition of two plumes of contaminated ground water which have migrated offsite. Area A was found to comprise an area of 6.3 hectares (15.5 acres) in the surficial aquifer and 2.4 hectares in the upper Floridan aquifer. The off-site areal plume within the surficial aquifer was found to extend approximately 150 meters (500 feet) south and 460 meters east of the CPI property. The plume in the surficial aquifer of Area B was found to extend approximately 150 meters south in the Cone Ranch property, covering an area approximately 5 hectares.[45] Phase II of CPI's contamination assessment, due for completion in the near future, is to include definition of the lateral and vertical extent of contamination.[46]

Seminole Fertilizer, in Bartow, Florida

The Seminole Fertilizer Corporation (formerly W.R. Grace & Company) Bartow Chemical Plant is located in central Polk County between the towns of Bartow and Mulberry. The plant began operation in 1954, and includes production facilities for phosphoric acid and phosphate and other fertilizers. The facility is underlain with three aquifers. The depth of the surficial aquifer ranges from 3 to 18 meters (10 to 60 ft). The intermediate aquifer ranges in depth from 18 to 61 meters. The typical depth at the facility to the uppermost useable aquifer (the Floridan) is approximately 61 meters.[47]

Waste management facilities at Seminole include one wastewater treatment plant, nine surface impoundments, two landfills, and two phosphogypsum stacks. The wastewater treatment plant, which is a two-stage liming facility, is used only during unusually intense rainfall events. Two surface impoundments are associated with the wastewater treatment plant: surface impoundment No. 1 is the primary liming pond and surface impoundment No. 2 is the secondary pond. Surface impoundment No. 3 occupies approximately 1.3 million square feet and is used as a cooling pond for process wastewaters, while surface impoundments Nos. 4-6 are a series of interconnected cooling ponds. The pH of the process water in the cooling ponds varies from 1.8 to 2.3, due to seasonal rains. Surface impoundments Nos. 7-9 are old clay settling ponds. Of the facility's two landfills, only one is currently in use. Landfill No. 1, occupying approximately 11 hectares (28 acres), is closed. Landfill No. 2 occupies 5 hectares and is used for filter cloths and solid materials not pumped to the gypsum stack.[48]

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[43] Consent Order, September 29, 1987, between the State of Florida Department of Environmental Regulation and Central Phosphates, Inc.

[44] Florida Phosphate Council, Joint Water Quality/RCRA Overview Committee, 1989, Groundwater Sampling Data.

[45] Ardaman & Associates, Inc., August 9, 1988, Contamination Assessment Report, Central Phosphates, Inc., Plant City Phosphate Complex, Hillsborough County, Florida.

[46] West Coast Regional Water, Supply Authority. 1990. Letter from M. Korosy to P. Bill, ICF, Re: Cane Beach Property, Hillsborough County, Florida; Draft Mineral Processing Waste Management Case Study on Central Phosphates, Inc., May 23.

[47] Seminole Fertilizer Corporation. March 27, 1989. "National Survey on Solid Wastes from Mineral Processing Facilities."

[48] Ibid.

The north gypsum stack, which first received waste in 1954, occupies approximately 65 hectares (159 acres) at an average height of 9 meters (28 ft). This stack receives process wastewater, phosphogypsum, gypsum solids from "tank clean out," and filter cloths. As of December 31, 1988, the north gypsum stack contained 14 million short tons of material. The south gypsum stack, which first received waste in 1965, occupies approximately 164 hectares at an average height of 14 meters. As of December 31, 1988, the south gypsum stack had accumulated 38 million metric tons of material.[49]

Activities at the Seminole Fertilizer Corporation facility have resulted in elevated levels of several parameters in ground water in the surficial and intermediate aquifers. This contamination has affected potable water wells in the area, some of which have been replaced with water from the City of Bartow's public supply.[50]

Seminole maintains eight monitoring wells as part of the ground-water monitoring system required for its state permit. Seminole has stated that MW-3 and MW-7 are up-gradient, background wells. All other wells are listed as down-gradient. The facility's ground-water data from September 1986 through March 1989 show that the down-gradient wells repeatedly exceeded the water quality standards for pH, gross alpha radiation, radium-226 and radium-228, iron, manganese, TDS, sulfate, cadmium, chromium, lead, and fluoride.[51]

On March 8, 1988, the Florida DER issued a warning notice to W.R. Grace & Company for violations of its ground-water monitoring permit during the third and fourth quarters of 1987. The standards for gross alpha radiation, radium-226 and radium-228, and sodium had been exceeded in some ground-water samples.[52] The analytical results showed the following maximum concentrations for each parameter: gross alpha, 107 pCi/L; radium-226 & -228, 14.4 pCi/L; and, sodium, 657 mg/L.

In addition to on-site wells, neighboring potable water wells have also been adversely affected. Analytical data from May 1988 show that 12 of 18 wells contained at least one contaminant at levels above the drinking water standards. Contaminants that were found in the samples included arsenic, lead, sodium, gross alpha, radium-226 and radium-228, iron, pH, sulfate, and total dissolved solids.[53] Potable water wells near the facility were replaced by a public water supply from the City of Bartow; W.R. Grace apparently paid for the water supply line installation and connection to the affected water users.[54]

Seminole has also received a warning notice from the Florida DER for an unpermitted discharge of process water from the facility to Bear Branch.[55]

Florida - Other

Management histories similar to those described for the above Florida facilities have also been documented by the Florida DER for CF Chemicals, Inc. and Farmland Industries, Inc. in Bartow, FL, and for Conserv, Inc. in Nichols, FL.

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[49] Ibid.

[50] Florida Department of Environmental Regulation. September 29, 1988. Conversation Record between B. Barker, Drinking Water Section, and K. Johnson, FDER.

[51] Seminole Fertilizer Corporation. June 1, 1989. Copy of facility's ground-water monitoring data from 9/86 to 3/89.

[52] Florida Department of Environmental Regulation. March 8, 1988. Warning Notice No. 53-88-03-061.

[53] W.R. Grace & Company. June 3, 1988. Letter from Glenn Hall, Environmental Engineer, W.R. Grace & Co., to Kirk Johnson, Florida Department of Environmental Regulation and ground-water monitoring data for private potable wells adjacent to the facility.

[54] Florida Department of Environmental Regulation. September 29, 1988. Conversation Record between Bob Barker, Drinking Water Section, and Kirk Johnson, FDER.

[55] Florida Department of Environmental Regulation. May 30, 1984. Warning Notice No. 53-84-05-327.

North Carolina

Texasgulf Chemicals, in Aurora, North Carolina

Texasgulf's phosphate plant is located six miles north of Aurora, Beaufort County, North Carolina, near the Pamlico River. Since at least 1973, Texasgulf Chemicals Company, an unincorporated division of Texasgulf, Inc., has engaged in the production of calcined and dried phosphate rock, sulfuric acid, phosphoric and superphosphoric acid, and other phosphate fertilizer ingredients at the Aurora plant.[56]

Waste management units include clay slurry settling ponds, two unlined cooling water ponds, gypsum stacks, and clay blend piles, which contain a mixture of clay and gypsum.

The process of purifying the ore involves the separation of very fine clay particles from the phosphate rock. The clays leave the separation process as a water based slurry that is referred to as "slimes." They are hydraulically transferred to settling ponds where the clear water fraction is separated and discharged. There are 5 settling ponds with discharges to South, Bond, and Long Creeks via 12 permitted outlets.[57]

Two cooling water ponds are used to recirculate process water through the phosphoric acid and fertilizer manufacturing areas, where it is primarily used in acid dilution, cooling, gypsum slurrying, and operation of emission control devices. Pond No. 1, with a surface area of 49 hectares (120 acres), began operation in November 1966. Pond No. 2, with a surface area of 24 hectares, began operation in late 1973.[58]

There are six gypsum stacks or piles located on the plant site. The stacks, which cover approximately 101 hectares, are surrounded by a ditch that returns excess water from the stacks to Pond No. 1. There are also a number of gypsum-clay blend piles (designated R-1, R-2, R-4, and R-5) on the site which are/were used in land reclamation activities.

The North Carolina Department of Environmental Management has recorded a number of incidents dating back to 1980 at the Texasgulf Chemicals Plant which may have resulted in negative environmental impact.[59] These incidents include violations of Texasgulf's effluent permit and spills from the facility. For example, violations of the effluent permit for daily maximum phosphorus and fluoride were recorded in 1980 on March 12, March 13, December 9, and December 11. Daily maximum permit limits are 9 mg/L for phosphorus and 10 mg/L for fluoride. Recorded concentrations for the four days ranged from 11 to 34 mg/L for phosphorus. Fluoride concentrations were 12 mg/L on March 12 and March 13. These violations occurred when contaminated wastewater from the toe ditch of the gypsum pile overflowed into the company's fresh water system. A spill of 150,000 cubic meters (40 million gallons) of gypsum stack decant water into a nearby fresh water canal occurred on January 4, 1987 when a retaining dike around one of the gypsum stacks failed. A 24-hour analysis of the canal water showed a pH drop to a low of 4.2, with a two-hour period when pH was below 6.0. At least 18 dead fish were counted along the canal.[60] The company was fined $1,000 for the incident by the State of North Carolina.[61]

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[56] NC-Environmental Management Commission (EMC). April 2, 1987. Findings and Decision and Civil Penalty Assessment.

[57] NC-Division of Environmental Monitoring (DEM). July 31, 1986. Memorandum from J. Mulligan to R.P. Wilms, Director, NC-DEM, Re: Texasgulf Chemicals Co., Beaufort County.

[58] Texasgulf. July 21, 1988. Preliminary Contamination Assessment at Cooling Ponds No. 1 and 2, Texasgulf Inc. Phosphate Operations, Aurora, North Carolina.

[59] NC-DEM. February 25, 1986. Memorandum from R.K. Thorpe to J. Mulligan, Washington Regional Office, NC-DEM, Re: Texasgulf Chemicals Company, Beaufort County.

[60] NC-DEM. February 10, 1987. Memorandum from R.K. Thorpe to L.P.Benton, Jr., Deputy Director, NC-DEM, Re: Fish Kill, Texasgulf Chemicals Co.

[61] NC-Environmental Management Commission (EMC). April 2, 1987. Findings and Decision and Civil Penalty Assessment.

Recent investigations have focused on leakage from cooling ponds Nos. 1 and 2, which have resulted in ground-water contamination of the first two water-bearing zones at the site.[62] In 1988, Texasgulf commissioned a Preliminary Contaminant Assessment for Cooling Ponds 1 and 2 in fulfillment of requirements for the renewal of a zero discharge permit. As part of this study, Texasgulf installed a total of 21 monitoring wells at the site in March and April of 1988. These monitoring wells included 10 wells at Cooling Pond No. 1, nine wells at Cooling Pond No. 2, and two background monitoring wells.[63]

Initial ground-water samples, obtained from monitoring wells at each of the cooling ponds during April 1988, show the results for the surficial aquifer and the Croatan Aquifer, which underlies the surficial aquifer at the site.[64] These results are displayed in Exhibit 12-6.

The first zone appears to be discharging to the facility's main effluent canal, while the direction of ground-water flow in the next zone is toward the northeast and Pamlico Sound.[65,66] Texasgulf subsequently began additional investigations to delineate the extent of contamination.[67] Initial results appear to support the initial conclusion that contamination is confined to the upper two water-bearing zones and that the Yorktown formation has prevented downward migration of contamination.[68] Texasgulf's Remedial Action Plan is currently under review by the NC-DEM.[69]

Louisiana

Agrico Chemical Co., Donaldsonville, Louisiana

AGRICO Chemical Company's Faustina Works phosphoric acid plant, which is located in Donaldsonville, Louisiana, began operations in 1974. Approximately 68 residents inhabit land within one mile of the facility. Receiving waters are the Mississippi River and the St. James Bayou.

Gypsum waste is slurried with process wastewater to a stacking area, where the solids settle out, and the water drains into adjacent ponds or clearwells.

This facility has experienced problems with elevated concentrations of phosphorus, fluoride and acid pH levels in surface and ground waters. Emergency discharges of untreated waters to surface water have occurred periodically throughout much of the 1980s; contamination of the ground water was reported in 1986.

EPA Region VI has prohibited the discharge of gypsum into the Mississippi River. About 1983, Agrico requested a modification of its NPDES Permit from EPA to allow Agrico to discharge gypsum to the Mississippi River under certain conditions. Agrico argued that the 1973 impoundment design was based on Florida facilities, and that the Louisiana climate and soils are different. Agrico stated that the height

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[62] Texasgulf. July 21, 1988. Preliminary Contamination Assessment at Cooling Ponds No. 1 and 2, Texasgulf Inc. Phosphate Operations, Aurora, North Carolina.

[63] Ibid.

[64] Texasgulf. July 21, 1988. Preliminary Contamination Assessment at Cooling Ponds No. 1 and 2, Texasgulf Inc. Phosphate Operations, Aurora, North Carolina.

[65] NC-DEM. December 13, 1988. Memorandum from B. Reid to A. Mouberry, Re: Texasgulf, Inc. Renewal of Permit No. 2982, Cooling Ponds Nos. 1 and 2.

[66] NC-DEM. January 17, 1989. Memorandum from R. Jones to C. McCaskill, Sup. State Engineering Review Unit, Permits and Engineering Branch, Re: Permit Renewal No. 2982 Cooling Ponds #1 and #2 Texasgulf, Inc.

[67] NC-DEM. December 13, 1988. Memorandum from B. Reid to A. Mouberry, Re: Texasgulf, Inc. Renewal of Permit No. 2982, Cooling Ponds Nos. 1 and 2.

[68] NC-DEM. June 3, 1989. Memorandum from B. Reid to R. Smithwick, Re: Texasgulf, Inc. Remedial Action Plan Cooling Ponds No. 1 and No. 2.

[69] Ardaman & Associates. February 6, 1990. Letter from T.S. Ingra and J.E. Garlanger to W.A. Schimming, Texasgulf, Re: Response to Deficiencies Noted by DEM Concerning the Cooling Pond No. 1 and No. 2 Remedial Action Plan and Proposed Revised Remedial Action Plan, Texasgulf Phosphate Operations.

Exhibit 12-6a
Ground-water Quality at Cooling Ponds 1 and 2 in the Surficial Aquifer Confined Sand Layer

Parameter	State Drinking Water Standard (mg/L)	Cooling Pond 1 (mg/L)	Cooling Pond 2 (mg/L)
Phosphorus (Total)	–	42.5 - 6,475	0.04 - 660
Fluoride	1.5	1.5 - 2,790	0.2 - 6.5
Chloride	250	151 - 189	20 -228
Sulfate	–	3,648 - 4,337	ND - 3,586
Total Dissolved Solids	500	5,685 - 27,783	255 - 4,444

Exhibit 12-6b
Ground-water Quality at Cooling Ponds 1 and 2 in the Croatan Aquifer Confined Shell Layer

Parameter	State Drinking Water Standard (mg/L)	Cooling Pond 1 (mg/L)	Cooling Pond 2 (mg/L)
Phosphorus (Total)	–	0.3 - 125	0.05 - 32
Fluoride	1.5	0.2 - 2.5	0.1 - 0.5
Chloride	250	32 - 184	11 - 71
Sulfate	–	374 - 2,447	2.9 - 436
Total Dissolved Solids	500	915 - 6,722	219 - 1,451

limitation meant that the original 240 hectares (600 acres), which would have lasted until about 1998 would now last only until 1989.[70]

In addition, Agrico stated further that "[a]nother related consequence is that the amount of contaminated run-off produced will increase geometrically as the impoundment acreage expands....Of the alternatives considered, only the "River Disposal/Partial Impoundment" option represents a reasonable and environmentally feasible alternative." Agrico concluded that "the water imbalance problem caused by continued total impoundment would result in an increased potential for the release of contaminated water."[71]

On April 15, 1983, a portion of Agrico's 62-foot gypsum stack failed structurally and released 230,000 cubic meters (60 million gallons) of water from its 40 hectare (100-acre) pond onto plant property.[72,73,74] The spilled water was pumped to another gypsum holding stack; concern over the potential failure of this stack, however, led Agrico to discharge the untreated water to the Mississippi River over a period of several weeks. These discharges exceeded permit limits.[75,76] After the pond failure, water of pH 2 was found flowing in an on-site drainage ditch at approximately 20 gpm into the St. James Bayou. The large volume of released water had destroyed a dam that controlled flow from the drainage ditch into the St. James Canal. Agrico reinstalled the dam on April 22, 1983, and transferred the low pH water still in the dammed section of the ditch back to the gypsum pond system. Agrico checked the water in St. James Canal, concluding that it did not seem affected by the low pH water discharged to it as a consequence of the April 15, 1983 gypsum pond failure.[77,78]

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[70] U.S. Environmental Protection Agency, Region 6. Undated. Report submitted by attorneys for Agrico Chemical Company, Kean, Miller, Hawthorne, D'Armond, McCow[illegible] & Jarman, and Hall, Estill, Hardwick, Gable, Collingsworth & Nelson, Re: Agrico Chemical Company, NPDES Permit LA0029769.

[71] Ibid.

[72] Agrico. 1983. Letter from R.A. Woolsey, Plant Manager to J. Dale Givens, Administrator DNR, Re: WPCD Inspection of the Faustina Facility on April 22, 1983.

[73] Louisiana DNR. May 11, 1983. Installation Inspection Forms, completed by Susan Stewart, Installation Representative.

Due to heavy rainfall, Agrico has continued to periodically perform emergency discharges of untreated stormwater from the clearwell, as occurred in March and again in June 1987. In its letter of notification, Agrico stated that "additional rain could result in catastrophic levee failure leading to loss of life, personal injury, or severe property damage."[79]

In March 1986, Agrico reported to LA DEQ that the water along the length of the north and east phosphogypsum perimeter ditches might be "slightly impacted" by phosphate, sulfate, and fluoride.[80]

In August 1986, Agrico submitted to LA DEQ a Hydrologic Assessment report for the Donaldsonville facility. LA DEQ regarded the reported situation as requiring corrective action: "Contamination of the shallow ground water, although by constituents which are not of great concern, poses a threat to drinking water. The Department's position is that the same physical characteristics that allow the contaminants to travel through the shallow silt faster than your theoretical model are present in the underlying clays."[81]

Even under non-emergency circumstances, Agrico has had difficulty keeping in compliance with NPDES permit limitations. In April 1987, an investigator reported that discharges from Agrico's inactive gypsum impoundment (Outfall 002) were in exceedance (up to 35 times) of permitted levels. However, the investigator determined that no action would be taken "until reissuance of new permit."[82]

In August 1987, LA DEQ determined that Agrico could not comply with the Louisiana Water Discharge Permit System that had been effective since March 1987.[83] LA DEQ issued an Administrative Order to Agrico to allow the facility to temporarily discharge water from gypsum stacks until standards were met.[84,85,86,87]

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[74](...continued)

[74] U.S. Environmental Protection Agency, Region 6. Undated. Report submitted by attorneys for Agrico Chemical Company, Kean, Miller, Hawthorne, D'Armond, McCowan & Jarman, and Hall, Estill, Hardwick, Gable, Collingsworth & Nelson, Re: Agrico Chemical Company, NPDES Permit LA0029769.

[75] Ibid.

[76] Louisiana DEQ. October 25, 1984. Memorandum from Patricia L. Norton, Secretary, to J. Dale Givens, Assistant Secretary, Re: Agrico Chemical Co.

[77] Agrico. April 29, 1983. Letter from R.A. Woolsey, Plant Manager to J. Dale Givens, Administrator DNR, Re: WPCD Inspection of the Faustina Facility on April 22, 1983.

[78] Louisiana DNR. May 11, 1983. Installation Inspection Forms, completed by Susan Stewart, Installation Representative.

[79] Agrico. June 17, 1987. Letter from R.A. Woolsey, Plant Manager to Myron O. Knudson, U.S. EPA Region 6 Director Water Management, Re: NPDES Permit Number: LA0029769. With attachment.

[80] Agrico. March 12, 1986. Letter from Susan P. Stewart, Manager, Energy and Environmental Control to Gerald Healy, Administrator, LA DEQ Solid Waste Division, Re: Agrico Phosphogypsum Site (P-0063) GD-093-0791.

[81] Louisiana DEQ. August 22, 1986. Letter from George H. Cramer, II, Administrator to Susan Stewart, Agrico Manager Energy and Environmental Control, Re: Hydrogeologic Assessment, Final Report GD-093-0791.

[82] U.S. Environmental Protection Agency, Region 6. 1986-88. NPDES Violation Summaries, from 10/18/86 - 4/12/88.

[83] Louisiana DEQ. August 17, 1987. Inter-office Letter, from G.S. Chambers to D.J. Miller, Re: Faustina Plant - Administrative Order.

[84] Ibid.

According to the LA DEQ, this facility has not experienced non-compliance or emergency release problems since those outlined in this section.

Arcadian, Geismar, Louisiana

This facility, formerly owned by Allied Chemical, has been operational since 1967. The plant is situated along the Mississippi River, in Geismar, Louisiana, northeast of the intersection of LA Highways 75 and 3115. Approximately 150 residents live within 1.6 km (1 mile) of the facility.[88] There are private drinking water wells within a 1.6 km radius of the facility.[89,90] The water table occurs at 24 meters (80 feet) below the land surface in the wet season, and 30 meters in the dry season.[91] The Mississippi River receives the discharges from this facility.

The phosphogypsum waste is slurried to the stack with process wastewater, which drains into a retention pond referred to as "the clearwell." There are four clearwells of differing sizes at the site, one of which is described as active. Six phosphogypsum stacks occupy the site as well, one or two of which appear to be active.

The effluent guidelines prohibiting discharge of process pollutants from a wet phosphoric acid facility were rescinded for the plants on the lower Mississippi due to poor soil stability and excess precipitation. EPA Region 6 described the condition as follows: "The withdrawal of the guidelines allowed the creation of the concept of active and inactive impoundments. The inactive impoundment drainage may be discharged directly to the receiving stream without limits provided no further wastes are sent to the inactive system and the discharge meets water quality standards."[92]

Two major categories of contaminant release to the environment have occurred at this facility: radioactivity releases to the ground water and clearwell discharges causing excessive phosphorus and fluoride loadings, as well as elevated pH, to surface waters. A third area of concern is fluoride fugitive emissions from the clearwell.

Arcadian has installed numerous monitoring wells throughout the gypsum stack and clearwell areas. Arcadian's ground-water monitoring report for the second half of 1988 showed gross alpha radiation in well P4 at 95 ± 31 pCi/L and 60 ±14 pCi/L in well P10.[93] The MCL for gross alpha radiation is 15 pCi/L. These releases are not extensively documented in the files reviewed; the documents reviewed did not discuss actions taken in response to the results presented.

The net surplus of precipitation in this region has prompted Arcadian to perform emergency discharges of excess water from its clearwell. Arcadian has justified this action by stating that until the NPDES permit effluent limitations are modified, there are no other environmentally acceptable alternatives

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[85] (...continued)

[85] Louisiana DEQ Water Pollution Control Division. 1987-88. Administrative Order issued by DEQ.

[86] U.S. Environmental Protection Agency. September 8, 1987. NPDES Compliance Inspection Report.

[87] U.S. Environmental Protection Agency, Region 6. 1988. Administrative Order, Re: Agrico Chemical Company, Docket No. VI-87-1411.

[88] Arcadian. April 21, 1989. "National Survey on Solid Wastes from Mineral Processing Facilities."

[89] Ibid.

[90] Gentry, J. January 20, 1989. Handwritten letter to LADEQ, Re: Questions and Comments on Permit Application.

[91] Arcadian. April 21, 1989. "National Survey on Solid Wastes from Mineral Processing Facilities."

[92] U.S. Environmental Protection Agency, Region 6. May 11, 1989. Letter from K.G. Huffman to M. Harbourt, of Kean et al, Attorneys at Law, Re: Arcadian Corporation, NPDES Permit No. LA0066257.

[93] Arcadian. January 15, 1989. Letter from J.J. Baker to T. Hardy, OSHW LADEQ, Re: ID #GD-005-1822 Ground Water Monitoring Report.

to the emergency bypass of the clearwell water.[94] The accumulation of facts throughout the documents suggests that excess water can cause failure of the gypsum stack or of the clearwell walls. During a discharge on February 27, 1987, Arcadian stated that the action was necessary "to prevent possible injury and severe property damage."[95] Such a discharge occurred again beginning on March 10 of the same year.[96] During these discharges, pH values ranged from 1.3 to 2.5; phosphorus concentrations from 3,688 mg/L to 7,960 mg/L; and fluorine concentrations from 6,188 to 14,649 mg/L.

An EPA NPDES Violation Summary, based on discharge monitoring reports from March 1986 to December 1987, showed that Outfall 003 violated effluent limits each month from at least December 1985 until August 1987. No enforcement action was taken for any of these violations. Since February of 1987, the EPA inspector has noted: "No action taken - waiting for an enforceable permit." Contaminant concentrations were similar to those listed above.

On December 8, 1988, EPA Region VI issued an Administrative Order to Arcadian regarding several violations, including the discharge on October 28 of that year of calcium sulfate run-off (Outfall 003) containing total phosphorus of 8,176 lbs/day, exceeding the permitted limit of 7,685 lbs/day.[97]

According to the LA DEQ, this facility has not experienced non-compliance or emergency bypass problems since those outlined in this section.

Louisiana -- Other

The management histories described for the above Louisiana facilities are also typical of the other Agrico facilities (Hahnville and Uncle Sam).

12.3.3 Findings Concerning the Hazards of Phosphogypsum and Process Wastewater

Based upon the detailed examination of the inherent characteristics of phosphogypsum and process wastewater arising from the production of wet process phosphoric acid, the management practices that are applied to these wastes, the environmental settings in which the generators of the materials are situated, and the numerous instances of documented environmental damage that have been described above, EPA concludes that current practices are inadequate to protect human health and the environment from the potential danger posed by these wastes.

Intrinsic Hazard of the Wastes

Review of the available data on phosphogypsum and its leachate constituent concentrations indicates that concentrations of 12 constituents exceed one or more of the screening criteria by more than a factor of 10, and that maximum chromium and phosphorus concentrations exceed the screening criteria by factors of greater than 1,000. In addition, two samples of phosphogypsum (out of 28) contained chromium concentrations in excess of the EP toxicity regulatory level, and phosphogypsum frequently contains uranium-238 and its decay products at levels that could present a high radiation hazard if the waste is allowed to be used in an unrestricted manner. This finding leads EPA to conclude that the intrinsic hazard of this waste is moderate to high.

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[94] Kean, et al, Attorneys at Law. November 6, 1984. Letter from M.N. Harbourt to J.V. Ferguson, EPA Region 6, Re: Notice of Anticipated Bypass, NPDES Permit No. LA0066257, Arcadian Corp., EPA File No. 7945-1.

[95] Arcadian. February 27, 1987. Letter from M.N. Harbourt to J. Van Buskirk, EPA Region 6 and J.D. Givens, LADEQ, Re: Notice of Anticipated Bypass and Request for Order Authorizing Bypass.

[96] Kean, et al, Attorneys at Law. March 19, 1987. Letter from M.N. Harbourt to J. Von Buskirk, EPA Region 6, Re: Arcadian Corporation - NPDES Permit Number: LA-0066257, EPA File Number: 7945-1.

[97] U.S. Environmental Protection Agency, Region 6. December 8, 1988. Cover letter from M.O. Knudson to H.J. Baker, Arcadian, Re: Administrative Order Docket No. VI-89-043, NPDES Permit No. LA0066257. 12/8/88. (Administrative Order attached).

Review of the available data on phosphoric acid process wastewater constituent concentrations indicates that phosphorus and phosphate are present at concentrations that sometimes are more than 100,000 times the screening criteria, arsenic and phenol are present at concentrations more than 1,000 times the screening criteria, and 15 additional constituents exceed a screening criteria by a factor of at least 10. In addition, process wastewater exhibits the RCRA hazardous waste characteristics of corrosivity (i.e., $pH < 2$) and exhibits the characteristic of EP toxicity (based on cadmium, chromium, and selenium concentrations). The wastewater also contains radium-226, gross alpha radiation, and gross beta radiation levels that could pose an unacceptably high radiation hazard if the wastewater is mismanaged. Based on these findings, EPA concludes that the intrinsic hazard of phosphoric acid process wastewater is high.

Potential and Documented Danger

The documented cases of dangers to human health and the environment indicate that phosphogypsum and process wastewater constituents have been released to ground water at a number of facilities and, at some sites, have migrated off-site to potable drinking water wells in concentrations that are well above hazard criteria. Based on the analysis of the damage case evidence, EPA concludes that management of phosphogypsum and process wastewater in stacks and ponds can release contaminants to the subsurface. Given the hydrogeologic setting and ground-water use patterns in the vicinity of most phosphoric acid plants, released contaminants threaten human health via potential drinking water exposures and render ground-water resources unsuitable for potential use.

Based on the analysis of the damage case evidence, it is clear that management of phosphogypsum and process wastewater in stacks and ponds can and does release contaminants to nearby surface waters. Given this evidence of releases, the proximity of most phosphoric acid plants to surface water bodies, and surface water use patterns, EPA concludes that at many phosphoric acid plants these released contaminants migrate to rivers and bays and threaten human health via drinking water exposures, threaten aquatic life, or render surface water resources unsuitable for potential consumptive uses.

EPA risk estimates demonstrate that phosphogypsum stacks pose a considerable air pathway cancer risk as a result of radon emissions from the stacks, with minor contributions from radioactive and nonradioactive constituents in windblown phosphogypsum. EPA estimates a maximum total air pathway lifetime cancer risk for a maximally exposed individual of approximately $9x10^{-5}$. This risk is primarily from inhalation of radon emitted from stacks ($9x10^{-5}$), with minor contributions from the inhalation of windblown phosphogypsum particles containing radionuclides ($2x10^{-6}$) and arsenic and chromium ($7x10^{-7}$).

12.4 Existing Federal and State Waste Management Controls

12.4.1 Federal Regulation

Section 3001(b)(3)(B)(iii) of RCRA provides the EPA Administrator with explicit authority to regulate the use of the use of solid wastes from phosphate rock processing for construction or land reclamation so as to prevent radiation exposure which presents an unreasonable risk to human health. EPA has not availed itself of this authority to date, but plans to consider regulatory options under this provision of RCRA to limit the off-site use in construction of elemental phosphorus slag, another special waste from mineral processing (see Chapter 7).

Off-site use of phosphogypsum has already been prohibited by the final National Emission Standards for Hazardous Air Pollutants (NESHAP) for radionuclides that was promulgated on December 15, 1989 (54 FR 51654). This rule requires that as of the effective date of the rule (March 15, 1990), phosphogypsum be disposed in stacks or in mined-out areas, effectively prohibiting use as a construction material or agricultural soil supplement.[98]

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations," which provide the basis for the minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of mineral processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT effluent limitations of process wastewater from wet-process phosphoric acid, normal superphosphoric acid, and triple superphosphoric acid include (40 CFR 418.12(c)):

Pollutant	Daily Maximum	Monthly Average
Total Phosphorus	105 mg/L	35 mg/L
Fluoride	75 mg/L	25 mg/L
Total Suspended Solids	150 mg/L	50 mg/L

Effluent limitations concerning the concentrations of pollutants contained in (1) the discharge of contaminated non-process wastewater after application of BPT and BAT (40 CFR 418.12(d) and 418.13(d)), (2) discharges of process wastewater related to phosphoric acid production from existing sources after application of BAT (40 CFR 418.13(c)), and (3) process wastewater from defluorination of phosphoric acid after application of BPT and BAT are identical and as follows (40 CFR 422.52(c) and 422.53(c):[99]

Pollutant	Daily Maximum	Monthly Average
Total Phosphorus	105 mg/L	35 mg/L
Fluoride	75 mg/L	25 mg/L

No discharges of process wastewaters from the production of phosphoric acid or from the defluorination of phosphoric acid are allowed from new sources.

In cases where the State does not have an approved NPDES program, such as Texas, Louisiana, and Florida, EPA Regional personnel have stated that EPA applies the above guidelines. However, EPA may also adopt State water quality standards for the management of these discharges, if applicable. In Idaho, which also does not have an approved NPDES program, the Federal guidelines listed above would apply. EPA Regional staff have not been available to confirm current policy regarding discharges from phosphoric acid facilities. The State of Florida does not currently have an EPA-approved NPDES program. Therefore, existing Federal regulations concerning the management of wastes from the production of phosphoric acid, would apply for facilities in this State. Wastes from phosphoric acid production are subject to the effluent limitation guidelines set forth in 40 CFR Part 418 Subpart A.

The Chevron Chemical Company phosphoric acid facility located in Rock Springs, Wyoming is situated on federal lands managed by the Bureau of Land Management (BLM). The Federal Land Policy and Management Act of 1976 (FLPMA, 43 USC 1732, 1733, and 1782) authorizes BLM to regulate mining activities on its lands with respect to the environmental effects of such activities. BLM regulations implementing this law (43 CFR 3809) are intended to prevent unnecessary or undue degradation of its lands, or lands that are under consideration for inclusion in the national wilderness system. These regulations provide for reclamation of lands disturbed by mining, hence, are not directly applicable to mineral processing activities.

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[98] On April 10, 1990 EPA published a Notice of Limited Reconsideration that provided a limited class waiver that allows continued use of phosphogypsum for agricultural uses for the duration of the current growing season, but not to extend beyond October 1, 1990. This notice also solicited comment on alternative uses of phosphogypsum, i.e., management practices other than disposal.

[99] The limitations for defluorination process wastewater also include daily maximum limits of 150 mg/L and 6-9 and monthly average limits of 50 mg/L and 6-9 for TSS and pH respectively.

12.4.2 State Regulation

The 21 facilities in the phosphoric acid sector are located in seven states, including Florida, Louisiana, Idaho, Mississippi, North Carolina, Texas, and Wyoming. All of these states except Wyoming were selected for regulatory review (see Chapter 2 for a discussion of the methodology used to select states for regulatory study). The majority of the 21 phosphoric acid facilities are located in Florida, Louisiana, and Idaho, which have twelve, three, and two facilities, respectively. Based on the distribution of facilities, therefore, state-level regulation of phosphoric acid processing wastes is of particular interest in the States of Florida, Louisiana, and Idaho.

As a general overview, six of the seven states with phosphoric acid processing facilities (all but Wyoming), adopt the federal exclusion from hazardous waste regulation for special wastes from mineral processing. Florida regulates wastes from the production of phosphoric acid under its solid waste rules, while Louisiana and Texas classify and manage such wastes as industrial solid waste. Mississippi and North Carolina exempt wastes generated in all types of mineral processing facilities from regulation as solid wastes. No requirements in Idaho's solid waste regulations apply to these wastes. Finally, three of seven states (North Carolina, Mississippi, and Wyoming) have EPA-approved NPDES programs while all seven states have air quality control regulations or standards that may be applicable to wastes from mineral processing facilities.

As noted above, most of the phosphoric acid processing facilities under study are located in Florida. Also as noted, Florida adopts the federal exclusion from hazardous waste regulation for mineral processing wastes. The state addresses phosphoric acid processing wastes under its solid waste regulations, though these regulations do not contain requirements pertaining specifically to phosphogypsum stacks or process wastewater cooling ponds. The state issues two types of permits for solid waste disposal activities at phosphoric acid facilities, including an industrial wastewater discharge permit (required for cooling ponds and maintained for some old stacks), and a solid waste disposal permit required of new stacks. Recent monitoring efforts have prompted the state to establish additional controls over stacks. Florida now requires that all discharges to ground water, in addition to established zones of discharge, be addressed by an appropriate permit. The state also applies modified landfill requirements, interim requirements, and limited wastewater facilities regulations, and is in the process of modifying the solid waste regulations with regard to design and operating standards, closure requirements, and financial responsibility requirements applicable to phosphogypsum stacks and cooling ponds.

Current regulation of phosphoric acid processing wastes in Florida, therefore, consists primarily of the requirement to obtain a permit for discharges to ground water and the requirement that new stacks and expansions of existing stacks be clay-lined and undergo formal closure. Under this policy, closure requirements include cover adequate to prevent infiltration and run-off controls. Further, all cooling ponds in the state must have run-on/run-off controls. The state also may place waste disposal location restrictions, performance standards, and operating requirements on a facility's solid waste disposal permit. The Florida Department of Environmental Regulation has the authority to conduct on-site inspections, issue administrative and consent orders, and require remedial action, though it does not have the authority to fine facilities for non-compliance. Finally, although air emissions from the phosphate industry are regulated under the state's air pollution rules, state officials indicated that phosphogypsum stacks typically crust over or are managed as part of a wet system so that fugitive dust emissions traditionally have not been considered a problem.

Louisiana, with three phosphoric acid processing facilities, also excludes mineral processing wastes from regulation as hazardous waste. Louisiana classifies and regulates mineral processing wastes as industrial solid wastes. Although no requirements have been drafted specifically for phosphogypsum stacks, facility owners/operators must comply with provisions for soils (e.g., stability, permeability), hydrologic characteristics, precipitation run-on and run-off, location standards, security, safety, and waste characterization. New stacks must have liners as well. During closure, the owner/operator must emplace a final cover or some alternate erosion control measure. Similarly, process wastewater cooling ponds must meet industrial waste surface impoundment requirements such as run-on controls, liner requirements, design standards (e.g., to prevent overtopping and minimize erosion), and waste characterization and ground-water monitoring requirements. Surface impoundments must be dewatered and clean-closed (i.e., all residuals removed) or closed according to solid waste landfill closure provisions. Owners/operators of both phosphogypsum stacks and process wastewater ponds must maintain financial responsibility for the closure and post-closure care of those units. In addition to these solid waste regulations, the three facilities in Louisiana must comply with federal NPDES permits and Louisiana Air Emissions Permits. Under the air permits, the facilities must be operated in a manner to minimize fugitive dust and could be required to undertake fugitive dust controls, such as the application of chemicals, asphalt, or water, if deemed necessary by the state. Finally, the state requires that owners/operators obtain a permit in order to construct a new facility or make a major modification to an existing facility.

Like Florida and Louisiana, Idaho, with two phosphoric acid processing facilities, excludes mineral processing wastes from its hazardous waste regulations. Unlike all of the other states with phosphoric acid processing facilities, however, Idaho does not apply any solid waste regulatory requirements to either phosphogypsum stacks or process wastewater cooling ponds. Moreover, the state does not have an approved NPDES program and, although the two facilities located in Idaho are broadly responsible for reasonable control of fugitive dust emissions, the state does not specifically address stacks or ponds in the facilities' air permits.

As noted, Mississippi, North Carolina, and Texas each have a single phosphoric acid facility and exclude those facilities from hazardous waste regulations. The facility located in Mississippi, which is not currently in operation, does have a current Mississippi NPDES permit. Because this facility disposes of its waste on site, however, the state does not require that the owner/operator obtain a solid waste management permit and does not plan to address the phosphoric acid wastes unless a threat to public health and the environment is demonstrated. The facility in North Carolina has a current North Carolina NPDES permit for its wastewaters. In accordance with a state-issued mining permit, the facility currently uses its phosphogypsum as fill for mined-out areas. The state does not regulate the stacks as solid wastes, but rather addresses them with non-discharge permits issued by the Water Quality Section of the Division of Environmental Management. North Carolina has initiated several consent agreements with the facility to address releases to surface and ground waters. The state also recently promulgated new air regulations that address radionuclide contaminants and may result in increased fugitive dust emission controls for phosphogypsum stacks. As with Mississippi, the facility in Texas has not been required to obtain a solid waste permit because it disposes of its wastes on property owned by the facility owner/operator. The facility has notified the state of its waste management activities, however, and has obtained federal NPDES and Texas wastewater discharge permits. Both North Carolina and Texas have addressed air emissions from phosphogypsum stacks only under general emission requirements. The final state with a phosphoric acid processing facility, Wyoming, was not studied in detail for this report. Wyoming appears to regulate its single facility under solid waste regulations and the state's approved NPDES program.

In summary, the two states with the most phosphoric acid processing facilities, Florida and Louisiana, appear to regulate those facilities most comprehensively. Of the remaining states, Mississippi, Texas, and Wyoming have placed fewer regulatory requirements on the phosphoric acid processing wastes managed within their borders, while Idaho has imposed essentially no requirements on the two facilities located within the state. In all cases, the wastes are addressed in general by NPDES, air, and solid waste landfill and surface impoundment requirements only, and not by regulations tailored specifically to phosphogypsum stacks or process wastewater cooling ponds.

12.5 Waste Management Alternatives and Potential Utilization

12.5.1 Waste Management Alternatives

Waste management alternatives, as discussed below, include alternative processes for manufacturing phosphoric acid and methods of purifying (i.e., reducing concentrations of radionuclides and/or other contaminants) the phosphogypsum so that it can be safely used in agriculture or construction. Direct recycling of phosphogypsum is not a viable alternative, because the phosphogypsum itself cannot be used in the production of phosphoric acid, although it is already common practice to recycle the process water used to slurry the phosphogypsum. One exception to this, as is discussed briefly in the section on utilization, is the production of sulfur dioxide (SO_2) by the thermal decomposition of phosphogypsum, which can be recycled to the manufacturing process as sulfuric acid.

Process Alternatives for Manufacturing Phosphoric Acid

There are a number of variations of the basic wet-acid process used to manufacture phosphoric acid. These alternative processes are considered in this section because the phosphogypsum that they generate may differ in its degree of hydration (hemihydrate vs. dihydrate) at the time of generation, which can determine which purification methods can be applied to the phosphogypsum, and how efficiently they can remove the impurities. In addition, the amount of preprocessing required before some types of utilization (e.g., as wall board or plaster) can also vary with the production process used. Unfortunately, there is insufficient data available to attempt an evaluation the volume, composition, or potential hazard(s) of the phosphogypsum generated by the different processes. Consequently, this discussion focuses on the differences that could be relevant to the subsequent treatment, utilization, or disposal of phosphogypsum generated by the different production processes.

Description

The processes to be discussed are the classic Prayon and Nissan-H processes which generate the dihydrate form of phosphogypsum ($CaSO_4 \cdot 2H_2O$); and the Central-Prayon and Nissan-C processes, which generate the hemihydrate form of phosphogypsum ($CaSO_4 \cdot ½H_2O$).

In the classic Prayon process, the dihydrate phosphogypsum is filtered out of the solution produced by the digestion of phosphate rock by sulfuric acid. The phosphogypsum is then pumped as a slurry to gypsum stacks for disposal.[100,101]

In the Central-Prayon process, the dihydrate phosphogypsum is filtered out of the solution produced by the digestion of phosphate rock by sulfuric acid. The phosphogypsum is converted to the hemihydrate form by heating it and adding sulfuric acid, whereupon the hemihydrate/phosphogypsum is extracted from the acid slurry by counter-current washing, and the liquid is recycled to the phosphate rock digestion process, and the hemihydrate slurry being sent to the stacks for disposal.[102]

In the Nissan-H process, the phosphate rock is digested by sulfuric acid at a high temperature which causes most of the phosphate rock to decompose and the hemihydrate form of phosphogypsum to be generat-

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[100] Pena, N., Utilization of the Phosphogypsum Produced in the Fertilizer Industry, UNIDO/IS.533, United Nations Industrial Development Organization (UNIDO), May 1985, p. 30.

[101] Muehlberg, P.E., J.T. Reding, B.P. Shepherd, Terry Parsons and Glynda E. Wilkins, Industrial Process Profiles for Environmental Use: Chapter 22. The Phosphate Rock and Basic Fertilizer Materials Industry, EPA-600/2-77-023v, Environmental Protection Technology Series, prepared for Industrial Environmental Research Laboratory, ORD, U.S. Environmental Protection Agency, February 1977, p. 21.

[102] Ibid., p. 31.

ed.[103] The hemihydrate slurry is cooled and recrystallized to dihydrate by using seed crystals of dihydrate phosphogypsum. This recrystallization step results in the formation of phosphogypsum crystals which can be easily filtered, and are believed to be of sufficient quality to be utilized in building materials without additional treatment.[104,105]

The Nissan-C process is very similar to the Nissan-H process, the main difference being that the hemihydrate slurry is recrystallized by both cooling it and changing its acid concentration, which results in phosphoric acid concentrations of 45-50 percent without evaporation (as opposed to the 30-35 percent normally produced by the dihydrate processes) and in a higher quality phosphogypsum.[106]

Current and Potential Use

It is uncertain which of the above processes are used by each of the phosphoric acid facilities, although EPA believes that at least two or three of the facilities use one of the processes (Central-Prayon or Nissan-C) which generate hemihydrate phosphogypsum, and that the rest of the facilities use one of the processes (classic Prayon or Nissan-H) which generate dihydrate phosphogypsum.

There do not appear to be any insurmountable obstacles preventing any of the facilities from using any of the available production processes. Some of the reasons why particular facilities use, or have converted to, a particular process have been that the hemihydrate processes are more energy efficient because the phosphoric acid that they produce is more concentrated (hence, requires less evaporative concentration, which is energy-intensive), and that the dihydrate processes are easier to control and maintain. If it becomes necessary to reduce the radionuclide content in the phosphogypsum (see the discussion of phosphogypsum purification below) so that it could be utilized rather than disposed (see section 12.5.2), facilities might have more incentive to begin using one of the processes which generate hemihydrate phosphogypsum, since the two purification methods which employ acid digestion require anhydrite or hemihydrate phosphogypsum.

Purification of Phosphogypsum

Utilization of phosphogypsum in construction and agriculture is constrained by the presence of impurities and hazardous constituents in the waste. Constituents such as radium-226 and arsenic may need to be removed because of the hazards they may present to human health and the environment, while phosphates and fluorides need to be removed for technical reasons related to the methods of utilization. The impurities include insolubles such as silica sand and unreacted phosphate ore; occluded water soluble phosphoric acid and complex fluoride salts; and interstitially trapped ions within the phosphogypsum crystal lattice, such as HPO_4^{2-}, AlF_5^{2-}, and radioactive radium-226.[107]

Description

Several processes for removing radium-226, as well as the other impurities, have recently been developed.[108,109] These processes involve either acid digestion of the phosphogypsum or simple physical removal of the more radioactive portions of the phosphogypsum.

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[103] Ibid., p. 14.

[104] Ibid., p. 16.

[105] The absence of supporting data has prevented EPA from evaluating the validity of this statement.

[106] Muehlberg, op. cit., p. 18.

[107] Palmer, J.W, and J.C. Gaynor, Phosphogypsum Purification, USG Corporation, Libertyville, Illinois, May 30, 1985, p. 1.

[108] Ibid.

[109] Palmer, J.W., Process for Reducing Radioactive Contamination in Phosphogypsum, U.S. Patent 4,338,292 to USG Corporation, June 14, 1983, p. 2.

The method of physical separation can reduce the radionuclide concentration of the phosphogypsum by approximately 30 percent. The method involves the use of a hydrocyclone to remove the phosphogypsum crystals smaller than 30 microns (which contain the greatest proportion of radionuclides) from the bulk of the phosphogypsum.[110]

While the two acid digestion processes are more complicated and costly, they can remove nearly all of the radioactive constituents. The acid digestion processes are similar to one another; the primary difference between the processes is whether anhydrite ($CaSO_4$) or hemihydrate ($CaSO_4 \cdot ½H_2O$) is used as a reaction intermediate in the purification sequence. Both processes can be applied to dihydrate phosphogypsum, although it must first be dehydrated with sulfuric acid.

During the anhydrite purification method, phosphogypsum is placed in concentrated sulfuric acid where it is dehydrated and reprecipitated as small anhydrite crystals. Most of the soluble ions are removed from the phosphogypsum, while the radium-226 is precipitated with the anhydrite. (Silica sand also remains with the solid anhydrite.) The anhydrite is rehydrated with a dilute solution of sulfuric acid at a temperature less than 43°C, and gypsum seed crystals are used to speed up the rate of hydration. The remaining anhydrite crystals, along with the radium-226, can be readily separated from the larger gypsum crystals, although some of the very small anhydrite crystals adhere to the surface of the gypsum crystals, which increases the radionuclide content of the purified phosphogypsum.

During the hemihydrate purification method, the hemihydrate slurry is cooled, purified gypsum seed crystals are added, and large crystals of purified phosphogypsum are produced. Most of the radionuclides remain in the hemihydrate crystals, and the large dihydrate phosphogypsum crystals are easily separated from the smaller hemihydrate crystals.

The dilute sulfuric acid, used to rehydrate the anhydrite or hemihydrate, contains phosphate value from the phosphogypsum that can be recovered at the phosphoric acid plant. Silica sand is removed from the slurry by hydraulic classification.

An approximately 99.5 percent pure phosphogypsum can be obtained using either of these two processes. The hemihydrate route gives a 1 pCi/g radiation level, while the anhydrite route gives a 3 pCi/g level. Natural gypsum typically contains 1 to 3 pCi/g radiation.

Current and Potential Use

In the literature reviewed by EPA, no evidence was found to indicate that any of the phosphoric acid facilities are currently purifying their phosphogypsum. Future use of the purification methods will primarily depend on how the regulations constrain the disposal and utilization of phosphogypsum (see section 12.5.2).

Of the three purification methods described above, the physical separation process has only limited potential use. Since the physical separation process will only remove 30 percent of the radium-226, the use of this process is limited to phosphogypsum containing 14 pCi/g or less of radium-226 (i.e., a 30 percent reduction from 14 pCi/g will yield 9.8 pCi/g). This is assuming that phosphogypsum with a radium-226 content of greater than 10 pCi/g could not be utilized (see 54 FR 13482, April 10, 1990).

Exhibits 12-7 and 12-8 summarize phosphogypsum radium-226 content on a regional and facility-specific basis. Facility-specific information was available for only 7 of the 21 phosphoric acid production facilities. It should be noted that phosphate ores processed in Louisiana, Mississippi, and Texas originate from Florida. The radium-226 content of the North Carolina phosphogypsum falls below the tentative threshold level of 10 pCi/g radium-226 and, therefore, would not require purification. Phosphogypsum generated in Florida, Idaho, Louisiana, and Mississippi have radium-226 concentration ranges too high for the physical separation process to purify more than a fraction of the phosphogypsum to a level below the threshold level. However, the phosphogypsum generated in Texas has a low enough radium-226 concentration that the method

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[110] Pena, N., Utilization of the Phosphogypsum Produced in the Fertilizer Industry, UNIDO/IS.533, United Nations Industrial Development Organization (UNIDO), May 1985, p. 32

Exhibit 12-7
Effect of Purification Methods on Ra-226 Concentrations in Phosphogypsum, Listed by State

State	Phosphogypsum Generated in 1988 (MT)[a]	Observed Ra-226 Content in Phosphogypsum (pCi/g)[b]	Ra-226 Content After Purification by Physical Separation (pCi/g)	Ra-226 Content After Purification by Acid Digestion	
				Using Anhydrite Phosphogypsum (pCi/g)	Using Hemihydrate Phosphogypsum (pCi/g)
Florida	29,777,000	5.9 - 36[c,d]	4 - 27	3	1
Idaho	2,646,000	7.9 - 23[d]	6 - 16	3	1
Louisiana	7,260,000	1.4 - 257[c]	1 - 160	3	1
Mississippi	474,000	5.9 - 36[d,e]	4 - 27	3	1
North Carolina	5,425,250	4.3 - 4.6	3	3	1
Texas	1,157,000	13.2 - 15.0	9 - 10.5	3	1
Wyoming	836,000	—	—	3	1

(a) Company responses to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities," conducted in 1989.

(b) 1989 Waste Characteristic data provided by industry in response to RCRA 3007.

(c) May, Alexander and John W. Sweeney, Assessment of Environmental Impacts Associated with Phosphogypsum in Florida, prepared for the U.S. Department of Interior, Bureau of Mines, RI 8639, p. 8.

(d) EG&G Idaho, Inc., Evaluation of Relative Hazards of Phosphate Products and Wastes, prepared for the U.S. Department of Energy, DOE Contract No. DE-AC07-76ID01570, March 1984, p. 18.

(e) The phosphate rock originates in central Florida.

Exhibit 2-8
Effect of Purification Methods on Ra-226 Concentrations in Phosphogypsum, Listed by Facility

Facility	State	Phosphogypsum Generated in 1988 (MT/YR)[a]	Observed Ra-226 Content in Phosphogypsum (pCi/g)[b]			Ra-226 Content After Purification by Physical Separation (pCi/g)	Ra-226 Content After Purification by Acid Digestion	
			Min	Med	Max		Using Anhydrite Phosphogypsum (pCi/g)	Using Hemihydrate Phosphogypsum (pCi/g)
Agrico in Unice Sam	LA	4,100,000	—	—	—	—	3	1
Agrico in Donaldson	LA	2,580,000	90	182.5	63 - 90	63 - 160	3	1
Arcadian in Geismar	LA	800,000	1.4	18.5	1 - 14	1 - 14	3	1
CF Chemicals in Bartow	FL	140,000	—	—	—	—	3	1
Conserv in Nichols	FL	1,100,005	5.8	5.9	4	4	3	1
IMS Fertilizer in Mulberry	FL	6,800,000	19	27	13 - 26	13 - 26	3	1
JR Simplot in Pocatello	ID	1,457,000[c]	7.8	—	6 - [illegible]	6 - 16	3	1
Texasgulf in Aurora	NC	5,425,250	4.3	4.5	3	3	3	1
Mobil Mining in Pasadena	TX	1,157,000	13.2	14.1	9 - 10.5	9 - 10.5	3	1

(a) Company responses to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities," conducted in 1989.
(b) 1989 Waste Characteristic data provided by industry in response to RCRA 3007.
(c) Reported value is confidential; estimate made using average waste to product ratio and facility capacity.

of physical separation should be able to reduce the radium-226 concentration below the 10 pCi/g threshold in most of the phosphogypsum generated.

Therefore, it appears that only a small portion of phosphogypsum produced annually could be sufficiently purified by the physical separation technique. In order to reduce all the phosphogypsum to a level at or below the 10 pCi/g threshold, the purification methods using acid digestion would be required.

Factors Affecting Regulatory Status

The residuals generated by the acid digestion purification of phosphogypsum have a specific activity of up to 600 pCi/g[111], and while the purification process generates a relatively low volume of waste, it is very concentrated and may pose disposal problems that equal or outweigh those associated with the original phosphogypsum. At this time, however, EPA does not have sufficient information to articulate a position on the regulatory status of this residue. One waste management strategy which has been suggested for immobilizing the radionuclides is to blend it with waste phosphatic clay suspensions (slimes) and allow the mixture to solidify.[112] The discussion in Section 12.5.2 on utilization of phosphogypsum in mine reclamation provides an explanation of this approach.

While no information was found on the volume or radium-226 concentration of the waste resulting from the physical separation method, it too would produce residuals with relatively high concentrations of radium-226.

12.5.2 Utilization

Described below are a number of alternatives for utilizing phosphogypsum. Some of these uses, such as agriculture and mine reclamation, already utilize significant amounts of phosphogypsum. Other alternatives (e.g., use as a construction material) have been shown to be technically feasible, but for a variety of reasons have not moved beyond the developmental stage of field testing in the U.S.

At the time of this assessment, it is uncertain which, if any, of the uses discussed below will be allowed. EPA currently requires that phosphogypsum be disposed in stacks or mines, which precludes alternative uses of the material,[113] except for a limited class waiver for the agricultural use of phosphogypsum, which will be in effect until October 1, 1990. EPA has, however, announced a limited reconsideration of the rule requiring the disposal of phosphogypsum in stacks or mines, and has also given notice of a "proposed rulemaking by which EPA is proposing to maintain or modify the rule to, alternatively or in combination, (1) make no change to 40 CFR Part 61, subpart R, as promulgated on October 31, 1989, (2) establish a threshold level of radium-226 which would further define the term "phosphogypsum", (3) allow, with prior EPA approval, the use of discrete quantities of phosphogypsum for researching and developing processes to remove radium-226 from phosphogypsum to the extent such use is at least as protective of public health as is disposal of phosphogypsum in mines or stacks, or (4) allow, with prior EPA approval, other alternative use of phosphogypsum to the extent such use is at least as protective of public health as is disposal of phosphogypsum in mines or stacks."[114]

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[111] Moisset, J., Location of Radium in Phosphogypsum and Improved Process for Removal of Radium from Phosphogypsum, Platres Lafarge (France) (date not known).

[112] Palmer, J.W. and J.C. Gaynor, Method for Solidifying Waste Slime Suspensions, U.S. Patent 4,457,781 to USG Corporation, July 3, 1984, p. 4.

[113] 54 FR 51654, December 15, 1989.

[114] 55 FR 13482, April 10, 1990.

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With respect to these four regulatory options, this report does not discuss options (1) or (3), other than to say that option (1) would preclude all of the alternative uses, with the possible exception of mine reclamation, and that it is unlikely that the option (3) would result in a significant reduction in the amount of phosphogypsum requiring disposal in mines or stacks.

Utilization of Phosphogypsum in Agriculture

Description

Phosphogypsum has been used in agriculture as a source of calcium and sulfur for soils that are deficient in these elements. Phosphogypsum is also incorporated into soils in order to provide sediment control for soils that have been eroded and leached to the point where they have developed a compacted crust. In addition, phosphogypsum is sometimes incorporated into acidic soils to serve as a buffering agent.

Phosphogypsum is sometimes pelletized before being applied to the soil, though the majority of phosphogypsum used for agricultural purposes is taken directly from disposal stacks, transported to local fertilizer companies, and distributed to the farmers. When the phosphogypsum is used as a fertilizer it is simply spread on the top of the soil, whereas when it is used for pH adjustment or sediment control it is tilled into the soil.

Current And Potential Use

It is estimated that 1,260,000 metric tons of gypsum are used in agriculture each year.[115] Of this amount, approximately 221,000 metric tons is from phosphogypsum stacks, 318,000 metric tons is from by-product gypsum processors, and 721,000 metric tons is from natural gypsum mines and quarries.[116]

As discussed above, EPA currently requires that phosphogypsum be disposed in stacks or mines, although a limited class waiver for agricultural use of phosphogypsum is in effect until October 1, 1990. After October 1, 1990, agricultural uses of phosphogypsum will not be allowed unless EPA decides to implement regulatory options (2) or (4) identified above.

If a threshold level of radium-226 is established (regulatory option (2)), it may be possible to utilize the phosphogypsum after purification (i.e., reducing the radium-226 content) (see section 12.5.1). If the physical separation method described in section 12.5.1 were used to purify phosphogypsum, the data displayed in Exhibits 12-7 and 12-8 suggest that some of the phosphogypsum generated in the states of Florida, Idaho, Louisiana, Mississippi, North Carolina, and Texas might have a radium-226 content below the threshold level of 10 pCi/g. However, the available data are not detailed enough for EPA to estimate how much of the purified phosphogypsum at each facility would fall below the threshold level. If either of the acid digestion purification methods (see section 12.5.1) were used to purify the phosphogypsum, the data in Exhibits 12-8 and 12-9 suggest that all of the phosphogypsum generated in the U.S. would have radium-226 concentrations below the threshold level.

Factors Relevant to Regulatory Status

A 1978 radiological assessment of the application of phosphogypsum to vegetable crop land concluded that there is little reason for concern regarding potential radiological hazards from the uptake of radium-226 by vegetable plants grown in soils treated with phosphogypsum.

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[115] McElroy, Christopher J., Petition of United States Gypsum Company for Partial Reconsideration and Clarification, and Opposition of United States Gypsum Company to the Petition for Partial Reconsideration and Request for Stay of the Fertilizer Institute, United States Gypsum Company, February 9, 1990.

[116] Ibid.

In a different study, data on the radium-226 content of phosphogypsum samples from Florida and Idaho were used to calculate the increase in radium-226 content of soil to which phosphogypsum is applied. The study found that the application of 1 metric tons of 40 pCi/g phosphogypsum to 1 hectare of land, and mixed in the soil to a depth of 20 cm, would increase the radium-226 content of the soil by 0.01538 pCi/g. Therefore, the application of phosphogypsum for the purpose of sulfur fertilization (assuming an application rate of 0.1 metric tons per hectare per year) would result in an increase in the soil's radium-226 content of 0.0015 pCi/g-year, while the application of phosphogypsum for the purpose of sediment control (assuming an application rate of 4.0 metric tons per hectare per year) would result in an increase in the soil's radium-226 content of 0.62 pCi/g-year. Over a period of 100 years, these application rates would cause radium-226 concentrations to increase by 0.15 and 6.2 pCi/g, respectively, as compared to the typical radium-226 content in soils of 1-2 pCi/g.[117]

Feasibility

It is uncertain whether future regulations will completely preclude the agricultural uses of phosphogypsum, or only limit when and how it may be used.[118] Since many farmers have continued to use phosphogypsum despite the prospect of new regulatory prohibitions, and concerns about the radium-226 found in phosphogypsum,[119] it is not unreasonable to assume that farmers would continue to use it in the future, if it remains economically competitive. However, if it becomes necessary to reduce the radium-226 content before it can be used, the additional costs are likely to reduce the amount of phosphogypsum used if purification would make phosphogypsum more expensive than the materials it competes with.

Utilization of Phosphogypsum for Mine Reclamation

Description

An alternative to the direct disposal of phosphogypsum in stacks and/or mines has been developed in which phosphogypsum is mixed with phosphatic clay suspension (a waste stream from the beneficiation of phosphate rock), and placed in a disposal site (generally the phosphate mine) where it consolidates and can be reclaimed by planting grass and trees.[120] The process begins by increasing the solids content of the phosphatic clay suspension to 10 percent; a portion of the dewatered clay is pumped to the phosphoric acid plant and mixed with phosphogypsum from the belt-filters; the clay-phosphogypsum mixture (blend) is put into a blend tank and additional phosphogypsum from the stacks and phosphatic clay suspension are added until there are approximately 3 parts phosphogypsum to 1 part clay; the resulting blend (35 percent solids) is pumped as a slurry to the disposal site; and after the blend has had approximately one year to dewater and consolidate, it is possible to plant grass and trees on the surface.[121]

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[117] Burau, R.G., Agricultural Impact of Radium-226 in Gypsum Derived from Phosphate Fertilizer Manufacture, October 1976.

[118] 55 FR 13482 April 10, 1990.

[119] Personal communication, Dr. Gary Gascho, University of Georgia Experiment Station, April 25, 1990.

[120] Palmer, Jay W. and A.P. Kouloheris, Slimes Waste Solidification with Hydratable Calcium Sulfate, paper to be presented at the University of Miami Civil Engineering Department Seminar on Phosphogypsum on April 25-27, 1984, p. 279.

[121] Personal communication, William A. Schimming, Environmental Affairs Manager, Texasgulf Inc., April 30, 1990.

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Current and Potential Use

Only Texasgulf's facility in Aurora, North Carolina is known to be using this management practice. To date, Texasgulf has used the phosphogypsum-clay blend to reclaim a 400 acre[122] portion of a phosphate mine adjacent to the facility, and is currently utilizing phosphogypsum at about the same rate as it is being generated.[123]

In considering whether any of the other 18 facilities could utilize their phosphogypsum in this way, there are at least two factors which need to be considered. The first factor is that the phosphoric acid plant be located near enough to the disposal site to keep transportation costs to a minimum. The second factor is that the phosphatic clay suspension contain sufficient base (e.g., calcium carbonate) to neutralize the acids in the phosphogypsum. Some of the facilities in Idaho and Florida may be close enough to their mines to utilize their phosphogypsum (total of 45,777,691 metric tons in 1988)[124] for mine reclamation, although this is not at all certain. The facilities in Louisiana, Mississippi, and Texas could not use this option to utilize their phosphogypsum (8,911,000 metric tons in 1988)[125] because their phosphate rock is mined in central Florida, nor could the Chevron Chemical facility in Rock Springs, Wyoming (836,000 metric tons phosphogypsum in 1988),[126] because its phosphate rock is mined in Utah. EPA does not know whether any of the phosphatic clay suspensions generated outside of North Carolina are sufficiently basic to neutralize the acids in the phosphogypsum.

Factors Relevant to Regulatory Status

EPA believes that the utilization of phosphogypsum to reclaim mines may have a number of advantages over the current practice of placing it in stacks or mines. Specifically, having grass and trees growing over the reclaimed mine will reduce the potential for the waste to be released to surface water by erosion, or to the atmosphere as wind blown dust. It should also reduce the demand for surface impoundments needed for the disposal of phosphatic clay suspension. Finally, the reclaimed disposal sites will be more aesthetically pleasing than the stacks and mines currently used to dispose phosphogypsum. While there are no obvious disadvantages, contaminant releases from areas reclaimed in this manner, particularly to ground water is a potential problem. EPA has not found any information regarding the migration of hazardous constituents from the phosphogypsum-clay blend into ground or surface waters.

The radiological and chemical composition of the phosphogypsum-clay blend will vary widely, due to differences in phosphate ore and manufacturing processes. Texasgulf believes that its phosphogypsum-clay blend has approximately the same radionuclide concentrations as the original phosphogypsum.[127] This belief is consistent with data from central Florida in which the concentration of radium-226 is 23.8 pCi/g in phosphatic clay suspensions, and 25.9 pCi/g in the phosphogypsum.[128] While not much data on the chemical, radiological, or physical characteristics of the phosphogypsum-clay blend is currently available, North Carolina State University's, Department of Soil Science is reportedly in the process of investigating these issues.[129]

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[122] The filled area was approximately 35 feet deep.

[123] Schimming, op. cit.

[124] Ibid.

[125] Company responses to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities," conducted in 1989.

[126] Ibid.

[127] Schimming, op. cit.

[128] Palmer, J.W. and A.P. Kouloheris, Slimes Waste Solidification with Hydratable Calcium Sulfate, Paper to have been presented at the University of Miami Civil Engineering Department Seminar on Phosphogypsum, April 25-27, 1984, p. 278.

[129] Schimming, op. cit.

Feasibility

It is likely that this management alternative will have a greater level of social acceptability than current practices, which result in large, barren disposal areas. EPA does not believe that the rule requiring that phosphogypsum be disposed in stacks or mines (thereby precluding alternative uses of the material) will preclude the use of this alternative, since it does not involve putting the phosphogypsum-clay blend anywhere except in stacks and mines.[130] The greatest barriers to the use of this alternative appear to be geographic and technical in nature (see the discussion on Current and Potential Use), although there may also be some economic barriers (e.g., current practices are less expensive).

Utilization of Phosphogypsum in Construction Materials

Phosphogypsum can be utilized as a construction material in a variety of ways. The two major areas of use are in building materials and highway construction. This section describes and evaluates applications in both areas.

Description

Phosphogypsum has the same basic properties as natural gypsum and may be used as a substitute for natural gypsum in the manufacture of commercial construction products. Approximately 70 percent of the natural gypsum used in the U.S. is for the manufacture of gypsum board or partition panels. Another 19 percent is used as an additive to cement. Addition of natural gypsum to cement retards the setting time, counteracts shrinkage, speeds the development of initial strength, and increases long-term strength and resistance to sulfate etching. The remaining 11 percent of all natural gypsum use is attributable to agricultural uses (7 percent) and miscellaneous uses including the manufacture of plaster and cement.[131] Phosphogypsum generated from the classic Prayon process for phosphoric acid production must be purified by removing phosphates, fluorides, and other impurities for it to be successfully used in the production of building materials or as an additive to cement, whereas phosphogypsum from the Central-Prayon, Nissan-H, and Nissan-C processes may often be used directly as natural gypsum substitutes without the need for purification.

Phosphogypsum from all four processes may often be used in the manufacture of cement without additional purification. One of the most promising processes for utilizing phosphogypsum in the manufacture of portland cement is the OSW-Krupp process, a modification of the Müeller-Kühne process. In this process, phosphogypsum is dried in a rotary dryer and mixed with coke, sand, and clay. The mixture is then ground, pelletized, and fed to a rotary kiln where SO_2 and clinker are formed. The SO_2 can then be passed to an acid conversion plant to produce H_2SO_4, which may be recycled to the phosphoric acid production process. The clinker is cooled and metered along with natural gypsum onto a belt conveyor feeding into a finished cement mill.[132]

Phosphogypsum generated from all phosphoric acid production processes may be used successfully as a road base, when stabilized with 5-10 percent portland cement or 15-25 percent fly ash, mixed with granular soil and compacted for secondary road construction, used in a portland cement concrete mixture and compacted to form roller-compacted concrete for paving driveways and parking areas, or used as fill and sub-base material.[133,134]

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[130] 54 FR 51654 December 15, 1989.

[131] Chang, W.F. and Murray I. Mantell, Engineering Properties and Construction Applications of Phosphogypsum, Phosphate Research Institute, University of Miami Press, Coral Gables, Florida, 1990, p. 6.

[132] Zellars-Williams Company, A.P. Kouloheris, principal investigator, Evaluation of Potential Commercial Processes for the Production of Sulfuric Acid From Phosphogypsum, Publication No. 01-002-001, Florida Institute of Phosphate Research, October 1981, pp. 18, 22.

[133] Ibid., pp. 177-189.

Current and Potential Uses

Currently, there are no major uses of phosphogypsum in the U.S. in the manufacture of building materials or in highway construction due to the low- cost availability of other suitable materials and to the ban on utilization of phosphogypsum under 40 CFR part 61, subpart R, National Emission Standards for Hazardous Air Pollutants, Radon Emissions from Phosphogypsum Stacks.

The U.S. has led the world in the mining of natural gypsum, with 20 percent of total world output. The cost of purifying and dewatering phosphogypsum and the relative abundance of natural gypsum has historically discouraged the development of phosphogypsum as a replacement for gypsum in the manufacture of building materials in the U.S.[135] It is unlikely that there will be a significant increase in the utilization of phosphogypsum in this capacity as long as there is a relatively abundant, low-cost supply of natural gypsum in the U.S.

Utilization of phosphogypsum in the production of H_2SO_4 and cement clinker would be possible in Florida. This application is most feasible where there is a shortage of sulfur and a high demand for cement. Its potential for success in Florida depends upon the sulfur market and the ability of a fertilizer company to market the cement clinker produced.[136]

Phosphogypsum has been successfully used on an experimental basis for paving and highway construction in both Texas and Florida. Phosphogypsum from Mobil's facility in Pasadena was stabilized with fly ash or portland cement and used as a road base on five test sections of city streets in La Porte, Texas.[137] In Polk County, Florida, the use of phosphogypsum as road base was demonstrated on a 2.4 km (1.5 mile) stretch of road, where it was mixed with granular soil and compacted prior to installation.[138] Another demonstration of using phosphogypsum as a road base occurred in Columbia County, Florida, where both 100 percent dihydrate phosphogypsum and mixtures of phosphogypsum-sand were used in a 2 mile stretch of road.[139] Phosphogypsum was also used as a component (13 percent) of roller-compacted concrete, which was used to pave 2,000 square yards of driveways and parking areas at the Florida Institute of Phosphate Research in Bartow, Florida.[140]

The actual commercial use of phosphogypsum as a road sub-base material has been demonstrated on a small scale in both Florida and North Carolina. In Florida it was used as sub-base roads at phosphorous processing facilities in central Florida, and as limestone substitute in the road sub-base of a section of blacktop road. In North Carolina it has been used as fill and sub-base in roads crossing swampy areas.[141]

Factors Affecting Regulatory Status

The primary regulatory concerns with respect to the disposal and utilization of phosphogypsum stem from its radium-226 content. The radium-226 is of sufficient concern that EPA currently requires phosphogypsum to be disposed of in a stack or mine, thereby precluding all of the construction uses discussed

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[134](...continued)

[134] Collins, R.J. and R.H. Miller, Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis, FHWA-RD-76-106, prepared for Federal Highway Administration, May 1976, p. 146.

[135] Fitzgerald, J.E., Jr. and Edward L. Sensintaffar, "Radiation Exposure from Construction Materials Utilizing Byproduct Gypsum from Phosphate Mining", (date not known), p. 353.

[136] Kouloheris, op. cit., p. 16.

[137] Chang, op. cit., p. 177.

[138] Ibid., p. 178.

[139] Ibid., p. 183.

[140] Ibid., pp. 186-187.

[141] Collins, op. cit. p. 146.

above. As is discussed at the beginning of this section, EPA is currently considering a number of regulatory options, two of which could conceivably allow phosphogypsum to be utilized in construction.

If a threshold level of radium-226 is established (regulatory option (2)), it may be possible to utilize the phosphogypsum after purification (i.e., reducing the radium-226 content) (see section 12.5.1). Assuming that the proposed threshold level of 10 pCi/g were adopted, and the physical separation method described in section 12.5.1 were used to purify the phosphogypsum, the data displayed in Exhibits 12-7 and 12-8 suggest that some of the phosphogypsum generated in the states of Florida, Idaho, Louisiana, Mississippi, North Carolina, and Texas might have a radium-226 content lower than the threshold value of 10 pCi/g. However, the available data are not detailed enough for EPA to estimate how much of the purified phosphogypsum would contain less radium-226 than the threshold level, or if phosphogypsum with a sufficiently low radium-226 concentration would be close enough to the potential markets for it to be economically competitive. Similarly, if one of the acid digestion purification methods (see section 12.5.1) were used to purify the phosphogypsum, the data in Exhibits 12-7 and 12-8 suggest that all of the phosphogypsum generated in the U.S. would have radium-226 concentrations lower than the threshold level.

It is not clear whether adoption of the fourth regulatory option would preclude the use of phosphogypsum in construction materials. It is likely that the determination of whether a particular use of phosphogypsum is at least as protective of human health and the environment as phosphogypsum disposal in stacks or mines, would have to be made on a case by case basis.

Feasibility

Even if it is allowed by the regulations, it is uncertain whether a significant amount of phosphogypsum would be utilized as a construction material. The basis for this conclusion is that even before the current constraints on the utilization of phosphogypsum were imposed, very little phosphogypsum has been used in construction; consumer concern over indoor radon is likely to discourage the use of products made from phosphogypsum, which may be perceived as a significant source of radon even if purified; natural gypsum is readily available in most parts of the U.S.; and there is concern about the exposure (e.g., via leaching and subsequent ingestion, see section 12.3.1) of humans to the hazardous constituents in phosphogypsum.

12.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for mineral processing special wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed under different regulatory scenarios by facilities producing wet process phosphoric acid. Next, the section discusses the cost implications of requiring these changes to existing waste management practices. The last part of the section discusses and predicts the ultimate impacts of the increased waste management costs faced by the affected facilities.

12.6.1 Regulatory Scenarios and Required Management Practices

Because the available data indicate that process wastewater and phosphogypsum may exhibit the hazardous waste characteristics of EP toxicity and/or corrosivity, these materials would in many cases be regulated as hazardous wastes under RCRA Subtitle C were it not for the the Mining Waste Exclusion. A decision by EPA that Subtitle C regulation is appropriate for these wastes would therefore result in incremental waste management costs. Accordingly, the Agency has estimated the incidence, magnitude, and impacts of these costs for the facilities that generate process wastewater and phosphogypsum from wet process phosphoric acid production; this analysis is presented in the following paragraphs.

EPA has adopted a conservative approach in conducting its cost analysis for the wastes generated by the phosphoric acid sector. The Agency has assumed that process wastewater would exhibit EP toxicity and corrosivity at all facilities unless actual sampling and analysis data demonstrate otherwise; EPA's waste sampling data, indicate that process wastewater exhibits at least one characteristic of hazardous waste at all facilities from which sampling data are available. Furthermore, because of current co-management of process waters at phosphoric acid facilities, the Agency has assumed that all process wastewaters managed at the facilities have similar chemical characteristics, that is, all circulating process water is assumed to be corrosive and/or EP toxic. In reality, the aggregate process wastewater stream may be separated into different process streams; only those that are potentially hazardous would require treatment. EPA's estimated compliance costs for managing process wastewater may, therefore, be overstated.

Similarly, in following a conservative approach, the Agency has assumed that phosphogypsum would exhibit EP toxicity at all facilities unless actual sampling and analysis data demonstrate otherwise. EPA's waste sampling data indicate that EP toxicity is not exhibited at 10 of facilities that generate the material; the Agency's cost and impact analysis of phosphogypsum management is, therefore, limited to eleven facilities, only one of which was both sampled and at which phosphogypsum constituent concentrations exceed one or more of the EP toxicity regulatory levels.

The Agency has estimated the costs associated with Subtitle C regulation, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus" (a more detailed description of the cost impact analysis and the development of these regulatory scenarios is presented in Chapter 2, above). In the following paragraphs, EPA discusses the assumed management practices that would occur under each regulatory alternative.

Process Wastewater

Subtitle C

Under Subtitle C standards, hazardous waste that is managed on-site must meet the standards codified at 40 CFR Parts 264 and 265 for hazardous waste treatment, storage, and disposal facilities. The Agency has assumed that the process wastewater and the phosphogypsum can and will be managed separately; non-hazardous process water is assumed to be used to transport the phosphogypsum to the management unit. Because phosphoric acid production process wastewater is a dilute, aqueous liquid, that is usually corrosive and often EP toxic, the management practice of choice under Subtitle C is treatment (neutralization and/or metals precipitation). The scenario examined here involves construction of a Subtitle C surge pond (double-lined surface impoundment) which feeds a system of concrete impoundments in which treatment is performed. Following treatment, the effluent may be reused by the facility (e.g., to slurry fluorogypsum to the gypsum stack or impoundment) just as it is under current practice. The sludge is assumed to be non-hazardous and is assumed to be disposed of in an unlined disposal impoundment or landfill.

Subtitle C-Minus

Assumed practices under Subtitle C-Minus are identical to those described above for the full Subtitle C scenario, with the exception that some of the requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements.

Subtitle D-Plus

Assumed practices under Subtitle D-Plus are identical to those described above for the Subtitle C-Minus scenario. Generators of process wastewaters are assumed to pose either moderate or high risk to ground water, even if, as is true in one case in the phosphoric acid sector, the environmental conditions indicate a low risk. Therefore, all facilities meet the same requirements under both Subtitle D-Plus and under Subtitle C-Minus; ground-water monitoring, a practice that is not required under the low risk Subtitle D-plus scenario, is assumed to be required in all cases.

Phosphogypsum

Subtitle C

Under Subtitle C standards, of hazardous waste that is managed on-site must meet the standards codified at 40 CFR Parts 264 and 265 for hazardous waste treatment, storage, and disposal facilities. The Agency has assumed that the phosphogypsum can and will be managed separately from the other special waste, process wastewater; non-hazardous process wastewater is assumed to be used to transport the phosphogypsum to the management unit. Because phosphogypsum is an inorganic solid that is transported in slurry form, the management practice of choice under Subtitle C is surface impoundment disposal. EPA has determined that because of Subtitle C closure requirements, existing waste management units (gypsum stacks) would not be permissible, because of the steep (nearly vertical) angles with which they are constructed. Closure of such units would require extensive contouring and regrading (so that they could be capped effectively), such that the total area occupied by the unit at closure would greatly exceed the space occupied during its operating life. The scenario examined here involves construction of a double-lined Subtitle C surface impoundment of significant size. The gypsum would be slurried to this impoundment in much the same way as it is currently slurried to gypsum stacks. Following settling of the suspended phosphogypsum, the transport water would be removed and piped back to the process operation for reuse, just as it is under current practice.

Subtitle C-Minus

Two primary differences are assumed to exist between full Subtitle C and Subtitle C-minus. The first is the assumption that facilities could use gypsum stacks if their use is less costly than using disposal impoundments. The second difference is the facility-specific application of tailored requirements based on potential risk to groundwater at affected facilities. Under the C-Minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating ground-water resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) would be necessary to protect human health and the environment. Ten of the 11 facilities assumed to generate potentially hazardous phosphogypsum were determined to have a high potential to contaminate ground-water resources; the eleventh was considered a low risk location.

When risk to ground water is high, facilities are assumed to be required to manage the waste in stacks lined with double synthetic liners and leachate collection and detection systems. As none of the ten facilities in high risk locations currently operate this type of unit, all would, under Subtitle C-minus, be required to build new stacks. In addition to the double composite liners, the stacks in high risk locations are required to have run-on/run-off controls and ground-water monitoring wells; both practices must be continued through the post-closure care period. In addition, the units must undergo formal closure, including a cap of topsoil and grass over a composite liner. Post-closure care must be maintained (e.g., mowing and general cap maintenance, and ground-water monitoring) for a period of 30 years.

At three of the ten facilities, where depth to groundwater allows for relatively deep impoundment construction, surface impoundment disposal of phosphogypsum is estimated to be the least cost management alternative. Composite-lined impoundments, requiring composite caps at closure, were assumed to be used at these facilities.

Chevron's Wyoming facility, the only facility in a low risk area (and the only facility at which phosphogypsum samples were determined to be EP toxic) was allowed to continue using its currently operating unit; the operator was assumed, however, to be required to install a ground-water monitoring system.

Subtitle D-Plus

As under both Subtitle C scenarios, facility operators under the Subtitle D-Plus scenario would be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to ground water increases. Under Subtitle D-Plus, the facilities are also allowed to operate gypsum stacks. The stacks do not require capping at closure under this scenario, under the assumption that the natural crusting of the gypsum that occurs as the material dries would be adequately protective. Because no capping, and therefore, no reduced slope angles, are required, the stacks are built with the same dimensions as the currently operating stacks, minimizing the total basal area required and, therefore, potentially decreasing the cost of compliance. Stacks at the ten high-risk facilities are assumed to require composite liners, single leachate collection systems, and ground-water monitoring. The one low-risk facility is assumed to continue operating its current stack. All eleven facilities are assumed to be required to install run-on/run-off controls and would continue the practice through the post-closure care period.

12.6.2 Cost Impact Assessment Results

Process Wastewater

Results of the cost impact analysis for the process wastewater generated by phosphoric acid facilities are presented by facility and regulatory scenario in Exhibit 12-9. Of the 21 facilities generating process wastewater, all are expected to incur costs under the Subtitle C regulatory scenario. Under this scenario, the annualized regulatory compliance costs would be $3.2 to $26.3 million greater than the baseline waste management costs, with a sector total of $225 million per year over baseline costs. Annualized new capital expenditures range from $1.1 to 11.7 million with a sector total of $101.8 million. At the majority of the facilities, capital costs account for 45 percent of the total annualized compliance cost, with the cost of wastewater tank treatment dominating overall costs.

Under the Subtitle C-Minus and D-Plus scenarios, the annualized compliance costs drop only slightly, due to relaxed technical standards for operation of the surge ponds used to hold the wastewater prior to treatment. Annualized compliance costs under Subtitle C-Minus range from $3.0 to $25.6 million; the sector total is estimated to be $215 million. Annualized costs under Subtitle D-Plus are nearly identical, with a

Exhibit 12-9
Compliance Cost Analysis Results for Management of Process Wastewater from Phosphoric Acid Production[(a)]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Agri Chem - Bartow, FL	296	5,849	15,488	2,311	5,537	13,781	2,056	5,434	13,781	2,056
Agrico Chemical - Donaldsonville, LA	287	12,131	39,213	5,851	11,677	36,708	5,477	11,677	36,708	5,477
Agrico Chemical - Mulberry, FL	298	11,098	32,239	4,811	10,654	29,795	4,446	10,551	29,795	4,446
Agrico Chemical - Uncle Sam, LA	314	15,541	50,321	7,509	14,975	47,193	7,042	14,872	47,193	7,042
Arcadian - Geismar LA	247	5,375	16,180	2,414	5,162	15,022	2,241	5,059	15,022	2,241
Central Phosphates - Plant City, FL	320	22,313	68,915	10,283	21,080	62,058	9,260	21,080	62,058	9,260
CF Chemicals - Bartow, FL	809	6,950	19,436	2,900	6,610	17,578	2,623	6,507	17,578	2,623
Chevron - Rock Springs, WY	281	4,760	12,439	1,856	4,504	11,043	1,648	4,402	11,043	1,648
Conserv - Nichols, FL	261	3,213	8,004	1,194	3,048	7,110	1,061	2,946	7,110	1,061
Farmland Industries - Bartow, FL	285	6,817	18,332	2,735	6,465	16,399	2,447	6,362	16,399	2,447
Gardinier - Riverview, FL	835	16,544	51,094	7,624	15,633	46,047	6,871	15,530	46,047	6,871
IMC Fertilizer - Mulberry, FL	326	26,309	79,067	11,798	25,619	75,236	11,226	25,516	75,236	11,226
Mobil Mining - Pasadena, TX	276	8,023	24,179	3,608	7,638	22,068	3,293	7,535	22,068	3,293
Nu-South Industries - Pascagoula, MS	519	7,871	26,091	3,893	7,491	24,013	3,583	7,388	24,013	3,583
Nu-West - Soda Springs, ID	269	5,743	16,424	2,451	5,464	14,899	2,223	5,361	14,899	2,223
Occidental Chemical - White Springs, FL	824	12,789	36,856	499	12,256	33,912	5,060	12,153	33,912	5,060
Royster - Mulberry, FL	524	8,506	17,902	2,671	6,192	16,183	2,415	6,089	16,183	2,415
Royster - Palmetto, FL	549	10,719	36,137	5,392	10,197	33,262	4,963	10,094	33,262	4,963
Seminole Fertilizer - Bartow, FL	520	12,948	37,186	5,549	12,434	34,356	5,126	12,331	34,356	5,126
JR Simplot - Pocatello, ID	555	5,369	14,958	2,232	5,093	13,452	2,007	4,990	13,452	2,007
Texasgulf - Aurora, NC	303	18,166	62,169	9,276	17,393	57,893	8,638	17,290	57,893	8,638
Total:	8,897	225,033	682,629	101,857	215,121	628,007	93,706	213,167	628,007	93,706
Average:	424	10,716	35,506	4,850	10,244	29,905	4,462	10,151	29,905	4,462

(a) Values reported in this table are those computed by EPA's cost estimating model and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Facilities evaluated here as generating potentially hazardous waste include those for which no sampling data exists.

sector total estimated at $213 million; the slight difference is due to differences in assumed permitting requirements and associated costs.

Phosphogypsum

Results of the cost impact analysis for the phosphogypsum generated by phosphoric acid producers are presented by facility and regulatory scenario in Exhibit 12-10. Of the 21 facilities generating phosphogypsum, a maximum of 11 may generate potentially hazardous waste and incur costs under the Subtitle C regulatory scenario. Under this scenario, the annualized regulatory compliance costs would range, for those eleven facilities, from $10.8 million to $185 million over and above baseline waste management costs, with a sector total of $684 million per year. Annualized new capital expenditures account for the vast majority (80 percent) of incremental costs, ranging from $8.4 million to $147 million greater than baseline, with a sector total of $542 million. The primary reason for these extreme compliance-related capital expenditures is the large size of the Subtitle C disposal impoundments that would be needed to contain a 15 year accumulation of phosphogypsum at most facilities.

Under the less rigorous, risk related technical requirements of the Subtitle C-Minus scenario, the annualized compliance costs would be $1.2 million to $65.3 million greater than the baseline waste management costs, with a sector total of $216.7 million per year. Annualized new capital expenditures would range from $0.4 to $51.2 million, with a sector total of $171 million. The decrease in compliance costs between the two Subtitle C scenarios is primarily a function of the assumption that modified stacks could be used under the Subtitle C-Minus scenario; the primary design modification involves a decrease in the slope of the stacks to allow for effective capping at closure. In addition, facilities located in low risk areas (one in this sector) could continue to operate their current stacks, and would simply be required to retrofit run-on/run-off controls and install ground-water monitoring systems. Facilities in high risk areas (the remaining ten facilities), incur higher costs due to requirements for double liners/leachate collection systems, increased basal area due to limitations on slope, and capping at closure. For three facilities, the costs of building new stacks that complied with these requirements were estimated to be higher than those of building similarly protective disposal impoundments; accordingly, for costing purposes, these facilities were assumed to build impoundments rather than gypsum stacks.

Under the Subtitle D-Plus regulatory scenario, the annualized compliance costs would be $0.48 to $62.2 million greater than the baseline waste management costs, with a sector total of $48.7 million per year. Annualized new capital expenditures would range from $0.1 to $52 million, with a sector total of $166 million. The distribution of costs is identical to that of the C-Minus scenario, while the overall magnitude of the costs is about 25 percent less. The primary reason for the decrease is that, because no capping is required, facilities can operate stacks with slopes identical to current practices; this reduces the basal area needed and hence, the costs of liners and leachate collection systems. In addition, the actual costs of capping are not incurred. As under Subtitle C-Minus, the one facility located in a low risk area is assumed to continue operating its current stack, but would retrofit needed controls. Ground-water monitoring is not required for this facility, due to its low risk location.

12.6.2 Financial and Economic Impact Assessment

In order to evaluate the ability of affected facilities to bear these estimated regulatory compliance costs, EPA performed an impact assessment which consists of three steps. First, the Agency compared the estimated compliance costs to the financial strength of each facility, to assess the relative magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, EPA conducted a qualitative evaluation of the salient market factors which affect the competitive position of the phosphoric acid producers, in order to determine whether compliance costs could be passed on to labor markets, suppliers of raw materials, or consumers. Finally, the Agency combined the results of the first two steps to predict the net compliance-related economic impacts which would be experienced by the facilities

Exhibit 12-10
Compliance Cost Analysis Results for Management of Phosphogypsum from Phosphoric Acid Production[(a)]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Agri Chem - Bartow, FL	409	17,310	90,806	13,549	11,760	60,101	8,968	11,645	64,067	9,560
Agrico Chemical - Mulberry, FL	1,057	41,386	220,518	32,904	20,455	110,917	16,550	11,906	66,627	9,942
Agrico Chemical - Uncle Sam, LA	3,856	99,755	534,386	79,737	65,361	343,515	51,257	62,242	352,204	52,553
Central Phosphates - Plant City, FL	1,547	185,043	985,328	147,023	30,180	164,700	24,575	17,887	101,203	15,101
Chevron - Rock Springs, WY	434	10,865	56,316	8,403	1,276	2,696	402	483	875	131
Gardinier - Riverview, FL	694	117,107	621,515	92,738	21,409	114,562	17,094	12,750	70,161	10,469
Mobil Mining - Pasadena, TX	962	46,859	247,207	36,886	12,877	68,198	10,176	7,428	40,059	5,977
Nu-South Industries - Pascagoula, MS	710	62,428	330,400	49,300	13,060	69,336	10,346	7,414	40,255	6,007
Nu-West - Soda Springs, ID	1,811	11,989	62,746	9,363	8,063	41,055	6,126	7,960	41,055	6,126
Occidental Chemical - White Springs, FL	1,298	27,712	149,079	22,245	18,916	100,310	14,968	18,813	100,310	14,968
Royster - Palmetto, FL	334	64,115	338,9[illegible]	50,582	13,362	70,715	10,552	7,661	41,498	6,192
Total:	13,112	684,588	3,637,295	542,730	216,738	1,146,105	171,013	166,188	918,313	137,024
Average:	1,192	62,235	330,663	49,339	19,703	104,191	15,547	15,108	83,483	12,457

(a) Values reported in this table are those computed by EPA's cost estimating model and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Facilities evaluated here as generating potentially hazardous waste include those for which no sampling data exists.

being evaluated. The methods and assumptions used in this analysis are described in Chapter 2 and in Appendices E-3 and E-4 to this report.

Financial Ratio Analysis

Process Wastewater

EPA believes that costs of compliance under full Subtitle C would have at least marginally significant impacts on all 21 facilities, as reflected by the screening ratio results in Exhibit 12-11. Annual compliance costs as a percent of value of shipments or value added are expected to be from one to five percent at 18 of the 21 facilities; for the remaining facilities, the screening ratio results range from five to seven percent. The compliance capital as a percent of annual sustaining capital is high for all 21 facilities, ranging from 14 to 73 percent. The financial impacts under prospective Subtitle C-Minus and D-Plus regulation would be similar in distribution and magnitude to those of the Subtitle C scenario.

Phosphogypsum

Regulation under Subtitle C would have a highly significant financial impact on any phosphoric acid facilities whose phosphogypsum is found to be hazardous (phosphogypsum was EP toxic at only one facility that was sampled, therefore, the remaining ten facilities for which costs were estimated might or might not actually experience impacts). As shown in Exhibit 12-12, the annualized incremental costs associated with waste management under Subtitle C represent 4 to 40 percent of both the value added and the value of shipments for all affected facilities generating potentially hazardous phosphogypsum. Moreover, the ratio of annual capital costs to annual sustaining capital investments also suggests severe impacts for these facilities, with screening ratio results ranging from 80 to 700 percent.

The financial impacts under Subtitle C-Minus regulation would be much less than under the full Subtitle C scenario. One facility, located in a low risk area, is estimated to incur no impacts under Subtitle C-Minus. Interestingly, this is the only facility for which waste sampling actually indicated EP toxicity. For the remaining ten facilities, impacts on the value of shipments or value added range from 3 to 13 percent.

Estimation of impacts under the Subtitle D-Plus scenario indicates that for three of the ten affected facilities, there is no difference from the Subtitle C-Minus scenario (the facility in the low risk area again experiences no impacts). One of the remaining seven facilities experiences only slightly lower impacts (5 percent less than C-Minus); the remaining six facilities experience reductions in the magnitude of impacts of 43 percent from the C-Minus scenario. Annualized capital as a percent of sustaining capital investments is high even under the Subtitle D-Plus scenario; screening ratio results for the ten affected facilities range from 55 to 229 percent.

Market Factor Analysis

General Competitive Position

The U.S. is the world's leading producer of phosphoric acid, the primary use of which is in fertilizers; other uses for phosphoric acid include nutrient supplements for animal feeds, builders for detergents, water softeners, additives for food, and pharmaceuticals. Domestic acid production is based on large quantities of high-quality phosphate rock reserves, located principally in Florida and North Carolina. These deposits provide abundant feedstock for high-quality phosphoric acid production. In recent years, Morocco has become the United State's main competitor in international markets. This competition has resulted in a downward price trend for phosphate in these markets. The fact that the U.S. is a major exporter of phosphate rock is an indication of the quality and relative cost of its phosphate reserves. However, low-cost, high-quality deposits do not guarantee profits in the phosphate rock and phosphoric acid markets. During difficult economic times, the use of phosphoric acid can decline despite being offered at a fairly low price. Fertilizer

Exhibit 12-11
Significance of Regulatory Compliance Costs for Management of Process Wastewater from Phosphoric Acid Production[a]

Facility	Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	CC/VOS	CC/VA	IR/K	CC/VOS	CC/VA	IR/K	CC/VOS	CC/VA	IR/K
Agri Chem - Bartow, FL	1.69%	1.87%	16.0%	1.60%	1.77%	14.2%	1.57%	1.74%	14.2%
Agrico Chemical - Donaldsonville, LA	3.06%	3.40%	35.5%	2.95%	3.28%	33.2%	2.95%	3.28%	33.2%
Agrico Chemical - Mulberry, FL	3.37%	3.74%	35.1%	3.23%	3.59%	32.4%	3.20%	3.56%	32.4%
Agrico Chemical - Uncle Sam, LA	2.83%	3.14%	32.8%	2.73%	3.03%	30.8%	2.71%	3.01%	30.8%
Arcadian - Geismar, LA	3.67%	4.08%	39.6%	3.53%	3.92%	36.8%	3.46%	3.84%	36.8%
Central Phosphates - Plant City, FL	3.91%	4.34%	43.2%	3.69%	4.10%	38.9%	3.69%	4.10%	38.9%
CF Chemicals - Bartow, FL	6.32%	7.03%	63.4%	6.02%	6.68%	57.3%	5.92%	6.58%	57.3%
Chevron - Rock Springs, WY	2.47%	2.75%	23.1%	2.34%	2.60%	20.5%	2.28%	2.54%	20.5%
Conserv - Nichols, FL	1.77%	1.97%	15.8%	1.68%	1.87%	14.1%	1.62%	1.80%	14.1%
Farmland Industries - Bartow, FL	1.55%	1.72%	14.9%	1.47%	1.63%	13.4%	1.45%	1.61%	13.4%
Gardinier - Riverview, FL	4.07%	4.52%	45.1%	3.85%	4.27%	40.6%	3.82%	4.25%	40.6%
IMC Fertilizer - Mulberry, FL	2.22%	2.46%	23.9%	2.16%	2.40%	22.7%	2.15%	2.39%	22.7%
Mobil Mining - Pasadena, TX	3.65%	4.06%	39.4%	3.48%	3.86%	36.0%	3.43%	3.81%	36.0%
Nu-South Industries - Pascagoula, MS	4.77%	5.31%	56.7%	4.54%	5.05%	52.2%	4.48%	4.98%	52.2%
Nu-West - Soda Springs, ID	2.61%	2.90%	26.8%	2.49%	2.76%	24.3%	2.44%	2.71%	24.3%
Occidental Chemical - White Springs, FL	1.98%	2.20%	20.5%	1.90%	2.11%	18.8%	1.88%	2.09%	18.8%
Royster - Mulberry, FL	2.47%	2.74%	24.4%	2.35%	2.61%	22.0%	2.31%	2.57%	22.0%
Royster - Palmetto, FL	6.09%	6.76%	73.6%	5.79%	6.43%	67.7%	5.73%	6.37%	67.7%
Seminole Fertilizer - Bartow, FL	2.91%	3.23%	30.0%	2.80%	3.11%	27.7%	2.77%	3.08%	27.7%
JR Simplot - Pocatello, ID	2.49%	2.76%	24.8%	2.36%	2.62%	22.3%	2.31%	2.57%	22.3%
Texasgulf - Aurora, NC	2.01%	2.24%	24.7%	1.93%	2.14%	23.0%	1.91%	2.13%	23.0%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays

[a] Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Facilities evaluated here as generating potentially hazardous waste include those for which no sampling data exists.

Exhibit 12-12
Significance of Regulatory Compliance Costs for Management of Phosphogypsum from Phosphoric Acid Production[(a)]

Facility	Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	CC/VOS	CC/VA	IR/K	CC/VOS	CC/VA	IR/K	CC/VOS	CC/VA	IR/K
Agri Chem - Bartow, FL	5.0%	5.5%	93.8%	3.4%	3.8%	62.1%	3.4%	3.7%	66.2%
Agrico Chemical - Mulberry, FL	12.6%	13.9%	239.8%	6.2%	6.9%	120.6%	3.6%	4.0%	72.4%
Agrico Chemical - Uncle Sam, LA	18.2%	20.2%	348.6%	11.9%	13.2%	224.1%	11.3%	12.6%	229.8%
Central Phosphates - Plant City, FL	32.4%	36.0%	618.2%	5.3%	5.9%	103.3%	3.1%	3.5%	63.5%
Chevron - Rock Springs, WY	5.7%	6.3%	104.8%	0.7%	0.7%	5.0%	0.3%	0.3%	1.6%
Gardinier - Riverview, FL	28.8%	32.0%	548.1%	5.3%	5.9%	101.0%	3.1%	3.5%	61.9%
Mobil Mining - Pasadena, TX	21.3%	23.7%	403.2%	5.9%	6.5%	111.2%	3.4%	3.8%	65.3%
Nu-South Industries - Pascagoula, MS	37.9%	42.1%	718.5%	7.9%	8.8%	150.8%	4.5%	5.0%	87.5%
Nu-West - Soda Springs, ID	5.5%	6.1%	102.3%	3.7%	4.1%	67.0%	3.6%	4.0%	67.0%
Occidental Chemical - White Springs, FL	4.3%	4.8%	82.8%	2.9%	3.3%	55.7%	2.9%	3.2%	55.7%
Royster - Palmetto, FL	36.4%	40.5%	690.0%	7.6%	8.4%	143.9%	4.4%	4.8%	84.5%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays

(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Facilities evaluated here as generating potentially hazardous waste include those for which no sampling data exists.

use is in part discretionary, and selection of types and amounts of various fertilizer types can vary. Despite its fairly competitive position versus other world suppliers, therefore, the profit margins for phosphoric acid and phosphate rock may often be somewhat restricted.

Throughout the 1990's, domestic production of phosphoric acid is expected to remain constant, while foreign production is expected to increase by less than 2.5 percent per year. Both domestic and foreign demand for phosphoric acid are expected to grow by less than 2.5 percent per year during the 1990's.

Potential for Compliance Cost Pass-Through

Labor Markets. There has been considerable restructuring in the phosphate industry with some associated wage concessions. The potential for further labor concessions is not known.

Lower Prices to Suppliers. The ability to pass through costs to input markets is not particularly relevant because the major phosphoric acid producers are integrated.

Higher Prices. Higher prices are generally difficult to impose except during periods of worldwide prosperity. The price of phosphate rock and phosphoric acid depends a great deal on competition from Morocco, the price of alternative fertilizers, and the use of slow release fertilizers.

Evaluation of Cost/Economic Impacts

EPA believes that regulation of phosphogypsum as a hazardous waste under RCRA Subtitle C would impose potentially severe impacts on facilities at which this waste exhibits EP toxicity; the number of such facilities is highly uncertain but is at least one and likely to be two or three. Mitigation of the severe cost impacts that would be experienced by the affected phosphoric acid producers under Subtitle C would be unlikely, because of the limited potential for compliance cost pass-through (at least 10 of the 21 active domestic producers would experience no impacts), and the operational reality that a substantial quantity (approximately five tons) of phosphogypsum is generated for every ton of phosphoric acid produced using the wet process. Therefore, EPA believes that regulation of phosphogypsum as a hazardous waste could pose a threat to the continued operation of any producer whose phosphogypsum tested EP toxic. Regulation under Subtitle C-Minus would also impose significant impacts at most facilities. The prospect of regulation of phosphogypsum under the Subtitle D-Plus scenario examined here would be unlikely to pose a threat to the continued viability of the majority of the phosphoric acid facilities. For 18 of the 21 active producers, no significant impacts would be incurred in managing phosphogypsum under Subtitle D-Plus regulations. At least three facilities, however, and one in particular, would be expected to incur significant impacts in managing phosphogypsum even under Subtitle D-Plus, potentially posing a threat to the economic viability of these facilities. One of those three facilities, however, is currently planning/constructing a new stack which is expected to be lined and employ a leachate collection system; estimated costs in meeting Subtitle D-Plus requirements may therefore actually have been incurred by that facility while this report was being prepared; in that event, Subtitle D-Plus regulation would not impose any costs or impacts on this facility.

The Agency also expects that regulation of process wastewater as a hazardous waste under both Subtitle C and C-Minus regulation could potentially pose a threat to the economic viability of affected domestic phosphoric acid producers, based on estimated compliance cost impacts; estimated impacts under the Subtitle D-Plus scenario are marginally lower. Because, however, all producers are expected to be affected, there is a greater potential for passing through costs to consumers in the form of higher prices for domestically produced acid than there would be if phosphogypsum were to be regulated as a hazardous waste. Eight of the 21 facilities managing potentially hazardous process wastewaters are predicted to incur significant impacts under the Subtitle D-Plus scenario. The significance of these impacts, as discussed above, is diminished by the possibility of the operators reducing waste generation or physically separating waste streams generated from different operations, in order to dramatically reduce the actual volume of water that would be hazardous and hence require treatment.

12.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) the potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of phosphogypsum is moderate to high in comparison to other mineral processing wastes studied in this report. Based on EP leach test results, 2 out of 28 samples (from 1 out of 8 facilities tested) contain chromium concentrations in excess of the EP toxicity regulatory levels. Chromium concentrations measured in SPLP (EPA Method 1312) leachate, however, were well below the EP regulatory levels. Phosphogypsum contains 12 constituents that exceed one or more of the screening criteria used in this analysis by more than a factor 10. Phosphogypsum solids may also contain uranium-238 and radium-226 in concentrations that could pose an unacceptably high radiation risk if the waste is allowed to be used in an unrestricted manner. For this reason, as part of its recently promulgated airborne emission standards for radionuclides (54 FR 51654, December 15, 1989), EPA has banned the off-site use or disposal of phosphogypsum in anything other than a stack or mine, with a limited waiver for agricultural uses. (See also 55 FR 13480, April 10, 1990.)

The intrinsic hazard of phosphoric acid process wastewater is relatively high compared to other mineral processing wastes studied in this report. Measurements of pH in 42 out of 68 process wastewater samples (from 10 of 14 facilities tested) indicated that the wastewater was corrosive, sometimes with pH values as extreme as 0.5. Based on EP leach test results, 19 out of 30 samples contain cadmium concentrations in excess of the EP toxicity regulatory level. In addition, 3 of 30 samples contain chromium concentrations in excess of EP toxicity regulatory levels. Phosphoric acid process wastewater also contains four constituents at concentrations that exceed one or more of the screening criteria used in this analysis by more than a factor of 1,000 and another 15 constituents exceed at least one relevant criterion by more than a factor of 10, including three radionuclides (i.e., gross alpha and beta radiation and radium-226).

Numerous documented cases of ground-water contamination indicate that phosphogypsum and process wastewater constituents have been released to ground and surface water at a number of facilities, and, at some sites, have migrated off-site to potable drinking water wells in concentrations that are well above criteria for the protection of human health. For example, in central Florida, the State Department of Environmental Regulation has initiated enforcement actions at all 11 active phosphoric acid production facilities because phosphogypsum stacks and process wastewater ponds have caused ground-water contamination above drinking water standards at the plant boundary or beyond. Based on the evidence of documented damages, EPA concludes that management of phosphogypsum and process wastewater in stacks and unlined ponds can release contaminants to the subsurface and that stack and dike failure can release contaminants to nearby surface waters. The combination of the intrinsic hazard of these wastes and the documented evidence of releases indicates that current management of phosphogypsum and phosphoric acid process wastewater may threaten human health through drinking water exposures, threaten aquatic life, and may render water resources unsuitable for potential consumptive uses. Although EPA estimates that phosphogypsum stacks pose an MEI lifetime air pathway cancer risk of as much as $9x10^{-5}$ as a result of radon emissions from the stacks, (with minor contributions from radioactive and nonradioactive constituents in windblown dust) the Agency concluded in its analysis of NESHAPs for phosphogypsum stacks that this level of risk is "acceptable."[142] Consequently, EPA promulgated a work practice standard for radon flux from phosphogypsum stacks that the Agency "belives existing stacks meet... without the need for additional control technology."[143]

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

At many active phosphoric acid production plants, current waste management practices and environmental conditions may allow contaminant releases and risks in the future in the absence of Subtitle C regulation. For example, the stacks and ponds are typically unlined and in the Southeast, where the phosphoric acid industry is most heavily concentrated, and ground water occurs in relatively shallow aquifers. While these surficial aquifers are not typically used for drinking water purposes, they frequently are hydraulically connected to aquifers or surface waters that supply drinking water. Similarly, catastrophic stack and dike failures and long-term seepage from stacks and ponds have released process wastewater and phosphogypsum constituents directly from management units to surface waters. Therefore, environmental releases can occur and, considering the intrinsic hazard of the wastes, significant exposures could occur if contaminated ground water is used as a source of drinking water.

The phosphoric acid production industry recently has been recovering from low production levels in the mid-1980's and may continue to expand somewhat in the future if fertilizer use continues to grow in response to increases in crop prices and planted acreage. Increases in production would likely be provided by increased capacity utilization at active plants (e.g., in 1988 three plants operated at utilization rates of 16 to 38 percent) and the reactivation of plants that are presently on standby. Therefore, if phosphoric acid production does increase, use of existing waste management units (both those at facilities evaluated in this analysis and those at idle facilities that were not included in this analysis) would expand, potentially increasing release potential and posing greater threats to human health and the environment. However, given the large quantities of these wastes, and the ban of off-site use of phosphogypsum,[144] it is unlikely that these wastes will be used or disposed in significant quantities at off-site locations in the future.

State regulation of phosphoric acid production wastes varies considerably among the seven states in which active plants are located, but requirements in most states may not be sufficient to control releases from existing units and prevent threats to human health and the environment. For example, relatively comprehensive solid waste regulations in Louisiana and Florida (under development) require liners and specify closure requirements for new and expansions of existing stacks, but the state programs provide controls for releases from existing units only through requirements for ground-water monitoring and performance standards that in some cases allow off-site contamination. In North Carolina, phosphogypsum and process wastewater are not defined as solid wastes, and are not subject to any solid waste regulations, though discharges from waste management units must be permitted under the state's EPA-approved NPDES program. In summary, state regulatory controls may not be sufficient to prevent releases of phosphogypsum and process wastewater constituents from existing units, and in only a few states are regulations that specify construction and operation standards in place or under development.

Costs and Impacts of Subtitle C Regulation

EPA has evaluated the costs and associated impacts of regulating both phosphogypsum and process wastewater from phosphoric acid production as hazardous wastes under RCRA Subtitle C. EPA's waste characterization data indicate that phosphogypsum exhibited the hazardous waste characteristic of EP toxicity at only one of the eight active facilities for which sampling data were available. EPA's data also indicate that process wastewater is either corrosive or EP toxic or both at each facility for which sampling data were available. Because of the relatively high potential for contamination as a result of the environmental settings of most phosphoric acid sites (e.g., shallow ground water) and the large number of damage cases associated with phosphoric acid production wastes, EPA employed the conservative assumption that phosphogypsum would be EP toxic at untested facilities, and that process wastewater would be both corrosive and EP toxic at untested facilities; the Agency's cost and impact estimates reflect this assumption and therefore probably overestimate the impacts of prospective regulation.

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[142] 54 FR 51675. December 15, 1989.

[143] Ibid.

[144] Ibid.

For phosphogypsum, costs of regulatory compliance under the full Subtitle C scenario exceed $10 million annually at all affected facilities and range as high as $185 million per year; these costs would impose potentially significant economic impacts on the operators of all affected plants. Application of the more flexible Subtitle C-Minus regulatory scenario would result in compliance costs that, on average, are approximately 60 percent lower, ranging from about $1 million to more than $65 million annually. Costs under the Subtitle D-Plus scenario are approximately 19 percent lower than under Subtitle C-Minus, because of further relaxation of waste management unit design and operating standards.

Subtitle C compliance costs would comprise a significant fraction of the value of shipments of and value added by phosphoric acid production operations at most affected facilities; ratios at seven of the eleven affected facilities exceed ten percent (five have ratios at or above 20 percent), while the remaining four exceed four percent. Compliance cost ratios under the Subtitle C-Minus and Subtitle D-Plus scenarios generally range from three to eight percent, though ratios at Agrico's Uncle Sam (LA) plant exceed eleven percent even under the least stringent scenario. EPA's economic impact analysis suggests that the domestic phosphoric acid industry is currently stronger than it has been in recent years, but would probably not be able to pass through compliance costs in the form of significantly higher prices to product consumers. Moreover, because not all domestic producers would be affected or affected equally, it is improbable that facilities experiencing high compliance costs would be able to obtain higher product prices in any case, given the relatively low rate of industry capacity utilization (77 percent overall in 1988). Therefore, if phosphogypsum were removed from the Mining Waste Exclusion, facilities at which this material was EP toxic might face new waste management costs (even under modified Subtitle C standards) that could threaten their long-term profitability and hence, their economic viability.

It is worthy of note that some impacts would be likely to occur even in the absence of a decision to remove phosphogypsum from the Mining Waste Exclusion, because adequately protective waste management standards under a Subtitle D program would require the construction of new waste management units at most facilities, implying significant new capital expenditures.

Based upon existing waste characterization data, EPA believes that all of the 21 facilities generating wet process phosphoric acid process wastewater might incur costs under a change in the regulatory status of this waste. Annualized regulatory compliance costs under Subtitle C would exceed $225 million, ranging from $4.7 to $26.3 million. Annualized new capital expenditures would account for approximately 45 percent of the total, with the cost of wastewater tank treatment dominating overall costs. Under the Subtitle C-Minus and D-Plus scenarios, the annualized compliance costs drop only slightly ($10-12 million in aggregate), due to relaxed technical standards for operation of the surge ponds used to hold the wastewater prior to treatment. The Agency expects that regulation of process wastewater as a hazardous waste under both Subtitle C and C-Minus regulation could potentially pose a threat to the economic viability of affected domestic phosphoric acid producers, based on estimated compliance cost impacts; estimated impacts under the Subtitle D-Plus scenario are marginally lower. The significance of these impacts might be diminished by the possibility of the operators reducing waste generation or physically separating waste streams generated from different operations, in order to reduce the actual volume of water that would be hazardous and hence require treatment.

Finally, EPA believes that incentives for recycling or utilization of phosphoric acid production wastes would be mixed if a change in the regulatory status of this waste were to occur. The predominant management alternative to disposal of phosphogypsum has been off-site use in construction applications and in agriculture. Because of the recently promulgate NESHAP banning such use, however, EPA expects that phosphogypsum will now be disposed on-site, regardless of the RCRA requirements that may be applied to such disposal, i.e., regulation under Subtitle C would affect only the costs of phosphogypsum management, not the type(s) of management techniques employed. Direct recycling of phosphogypsum for additional product recovery is not a viable option, and process changes that might affect the chemical properties of the material as well as purification methods have been employed with variable success. It is likely that in response to new regulatory requirements, facility operators would develop and implement measures to render their phosphogypsum non-EP toxic. Process wastewater is currently internally recycled at all active facilities. The potential for reducing the amount of water used and/or significantly reducing the total quantities of corrosive or otherwise hazardous substances currently found in process wastewater is extremely limited, given the nature of wet process phosphoric acid production operations.

Chapter 13

Titanium Tetrachloride Production

For purposes of this report, the titanium tetrachloride ($TiCl_4$) production sector consists of nine facilities that, as of September 1989, were active and reported generating a special mineral processing waste: chloride process waste solids. At one of these facilities (Timet at Henderson, NV) the $TiCl_4$ produced is used as feed material to manufacture titanium sponge metal. Two other titanium sponge producers, RMI and Ormet, reported no generation of the special waste and purchase rather than produce their mineral-related feedstock ($TiCl_4$).[1] Therefore, they are not addressed in this report.

At the remaining eight $TiCl_4$ facilities, the $TiCl_4$ produced is used as feed material to produce titanium dioxide (TiO_2) pigment by a process known as the "chloride process." Chloride process waste solids are generated during chlorination at all eight facilities. Adjacent to two chloride process facilities are two sulfate process TiO_2 pigment plants. The sulfate process wastes are not special mineral process wastes, therefore, these sulfate process plants and their wastes are not addressed further in this report. The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

13.1 Industry Overview

Titanium tetrachloride is used as a feedstock to two major processes, production of titanium dioxide and titanium sponge. Titanium dioxide is used primarily as a pigment in the paper and paint industries;[2] titanium sponge, produced in much smaller volumes than TiO_2, is used primarily in aircraft engines and airframes.[3] In the chloride process, high titanium concentrates are reacted with chlorine gas at high temperature. The resulting titanium tetrachloride gas is condensed, purified by distillation, and then either oxidized to titanium dioxide or reduced to titanium sponge. The nine active facilities are located across the U.S., as shown in Exhibit 13-1.

Exhibit 13-1
Domestic Titanium Tetrachloride Producers

Owner	Location	Ore Type
E.I. duPont	Antioch, CA	Rutile
E.I. duPont	Edgemoor, DE	Ilmenite
E.I. duPont	New Johnsonville, TN	Ilmenite
E.I. duPont	Pass Christian, MS	Ilmenite
Kemira	Savannah, GA	Rutile
Kerr-McGee	Hamilton, MS	Synthetic Rutile
SCM	Ashtabula, OH	Rutile, S. African Slag
SCM	Baltimore, MD	Rutile, S. African Slag
TIMET	Henderson, NV	Rutile

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[1] According to BOM sources, RMI is planning to build its own $TiCl_4$ facility, to be completed by year-end, 1991.

[2] The paper industry primarily uses TiO_2 produced by the sulfate process, which is not addressed in this report.

[3] Lynd, Langtry, 1990. Personal communication, June 27, 1990.

Titanium metal and titanium dioxide production have steadily increased throughout the late 1980's. Between 1985 and 1989, titanium metal production increased by 12 percent from 21,000 metric tons to 24,000 metric tons. Production in 1989 was about 85 percent of capacity for the year. Demand for titanium mill products also increased, mainly because of the continued boom in orders for new commercial airliners and expansions in the pulp and paper and chemical industries. While imports for consumption dropped in 1989, exports of titanium metal increased. In 1989, two companies completed expansion of their capacity, bringing total U.S. capacity to approximately 28,000 metric tons. One company announced plans for further expansion from 5,400 metric tons per year to 8,000 metric tons per year by March 1991.[4]

U.S. production of titanium dioxide pigments increased approximately 8 percent in 1989 from 926,746 metric tons, to 1,007,000 metric tons, setting a new record-high level for the seventh consecutive year. Consumption eased slightly but was close to the record level reached in 1988. Domestic producers increased total capacity by approximately 125,000 metric tons, via process optimization as well as major expansions. Additional new capacity planned to be on-line in 1990-91 totals about 240,000 metric tons, which would increase total U.S. capacity to approximately 1,300,000 metric tons.[5]

Demand for titanium and titanium dioxide are closely tied to the overall economy. Future demands depend upon the health of the economy in the 1990s. In 1989, about 80 percent of the titanium metal consumed was used in jet engines, airframes, and space and missile applications, while about 20 percent was used in the chemical-processing industry, power generation, marine and ordnance, medical, and other non-aerospace applications. Also, in 1989 approximately 48 percent of the titanium dioxide consumed was used in paint, varnishes, and lacquers; the remaining use of titanium dioxide was divided between paper (24 percent), plastics (17 percent), rubber (2 percent), and others (9 percent).[6] Industry sources indicate that world demand for titanium will grow at approximately 3 percent per year for pigment and 5 percent for metal for the next several years.[7]

Four of the titanium dioxide facilities are owned by one company, E.I. duPont de Nemours, two by SCM (which also operates a sulfate process plant), and one each by Kerr-McGee and Kemira (which also operates a sulfate process plant). Timet produces titanium sponge using the chloride process. All of the capacity and production data that were submitted by facility operators in response to the 1989 SWMPF Survey have been designated confidential by the individual respondents. Therefore, EPA has relied upon information from published sources to develop the necessary estimates for the analyses that follow.

Total titanium tetrachloride capacity is estimated to be 1.8 million metric tons per year. Approximately 41,000 metric tons of this capacity is the Henderson facility that primarily uses the product as a feedstock for titanium sponge production. The remaining capacity is at facilities whose primary use of the product is in production of titanium dioxide; a small portion of titanium tetrachloride produced at these facilities is sold for other uses. The Bureau of Mines estimates the long-term capacity utilization for these facilities to be 100 percent of capacity; 1988 capacity utilization at the Henderson facility was reportedly 87 percent of capacity or about 36,300 metric tons of titanium tetrachloride. The Bureau of Mines has reported that increased capacity of approximately 600,000 metric tons of titanium tetrachloride for use primarily in the production of titanium dioxide is expected by 1992.

Production of titanium tetrachloride involves chlorination of a titanium concentrate. The type of concentrate, however, may vary greatly between different companies and facilities, as shown in Exhibit 13-1. duPont's Antioch facility and the Kemira and SCM facilities use rutile, a high-grade concentrate containing approximately 95 percent titanium dioxide.[8] The SCM facilities may also use, in addition to rutile, a South African slag as a feedstock[9] that contains approximately 85 percent TiO_2.[10] In addition to rutile, ilmenite, a lower grade mineral with TiO_2 content ranging from 45-65 percent, which is typically routed to the sulfate process, may also be used in the chloride process. Kerr-McGee's Mobile facility beneficiates Australian ilmenite to produce a synthetic rutile that is shipped to its Hamilton facility for chlorination. The three remaining duPont facilities use a high-grade ilmenite in a one-step "ilmenite-chlorination process."[11]

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[4] Langtry E. Lynd, U.S. Bureau of Mines, Mineral Commodity Summaries, 1990 Ed., p. 180.

[5] Ibid.

[6] Ibid.

[7] "Titanium: The Market is - in the Air," E&MJ, March 1990, p. 41.

Irrespective of the feedstock type or source, in a typical titanium tetrachloride operation, as shown in Exhibit 13-2, the ore is chlorinated in a fluidized-bed reactor in the presence of coke. The volatile metal chlorides are collected and the special waste, the non-volatile chlorides and the unreacted solids that remain, are discharged. The gaseous product stream is purified to separate the titanium tetrachloride from other chlorides. Acidic liquid waste streams, primarily ferric chlorides, are the primary liquid waste stream from this purification process; these are, however, not special wastes. Vanadium oxychloride, another low volume non-special waste, is not removed from titanium tetrachloride by distillation; rather it is separated by complexing this material with mineral oil followed by reduction with hydrogen sulfide, or by complexation with copper. The purified titanium tetrachloride is then oxidized to titanium dioxide or reduced to titanium sponge and the chlorine gas liberated by this process is typically recycled.[12] The non-volatile chlorides and the unreacted process solids that remain after the reaction in the fluidized-bed reactor are the special waste under study in this report. These solids, suspended in chloride process waste acids, are treated and discharged. As noted in the January 23, 1990 final rule (54 FR 2322), the slurried residue from the "chloride-ilmenite" process reportedly employed by three titanium tetrachloride production facilities are considered to be chloride process waste solids.

13.2 Waste Characteristics, Generation, and Current Management Practices

The special mineral processing waste generated by titanium tetrachloride processing is chloride process waste solids. The solids are typically generated in a slurry with waste acids; the solids in the slurry are particles with a diameter less than 0.02 mm (smaller than sand). The solids in this slurry are the special waste; the waste acid is not a special waste and is not discussed in this report.

Eight of the nine companies generating this waste requested that waste generation rate data be regarded as confidential business information; therefore, no facility-specific waste generation data are presented in this report. The aggregate annual industry-wide generation of chloride process waste solids by the nine facilities was approximately 414,000 metric tons in 1988, yielding a facility average of nearly 46,000 metric tons per year. Ratios of metric tons of chloride solids to metric tons of titanium tetrachloride produced range from 0.07 to 0.80 and average 0.208 for the sector.

Using available data on the composition of chloride process waste solids, EPA evaluated whether the waste solids exhibit any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, the Agency does not believe the waste solids are corrosive, reactive, or ignitable, but some solids exhibit the characteristic

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[8] Lynd, 1988. Personal communication, Langtry Lynd, Titanium Commodity Specialist, U.S. Bureau of Mines, Washington D.C., August, 1988.

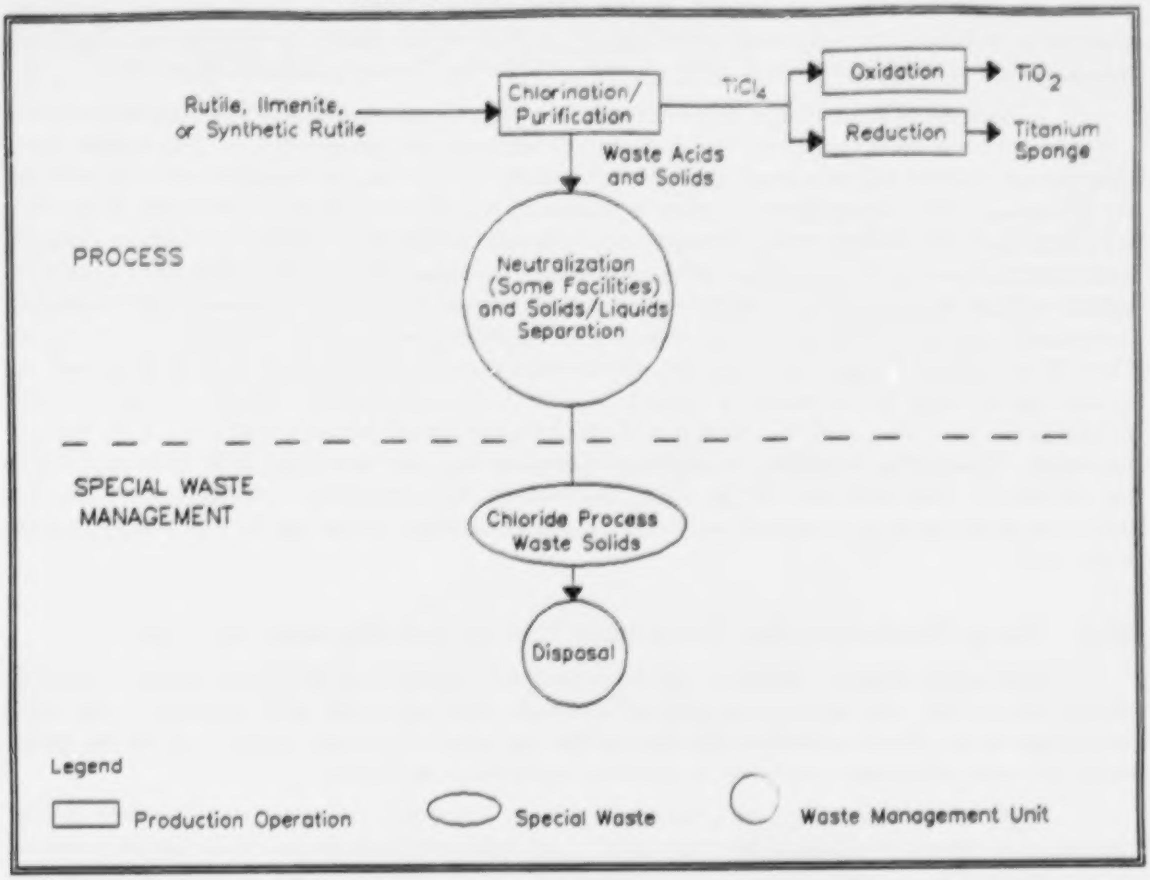
[9] Ibid.

[10] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 865.

[11] E.I. duPont de Nemours, 1989. Public comments from duPont addressing the 1989 proposed Reinterpretation of Mining Waste Exclusion (Docket No. – MWRP00023); May 31, 1989, pp. 7-8.

[12] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Antimony, Magnesium, Tin, and Titanium Smelting and Refining Industries. Prepared by PEI Associates for the U.S. EPA, December 1984.

Exhibit 13-2
Titanium Tetrachloride Production*


Rutile, Ilmenite, or Synthetic Rutile
Chlorination/ Purification
$TiCl_4$
Oxidation
TiO_2
Reduction
Titanium Sponge
Waste Acids and Solids
PROCESS
Neutralization (Some Facilities) and Solids/Liquids Separation
SPECIAL WASTE MANAGEMENT
Chloride Process Waste Solids
Disposal
Legend
Production Operation
Special Waste
Waste Management Unit

* And Related Activities (i.e., Ti02 and Titanium Sponge Production)

of EP toxicity. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for waste solids from six of the nine facilities of interest (data on mercury concentrations were available from only three facilities). Of these constituents, only chromium and lead concentrations were found to exceed the EP toxicity levels. Of the 16 samples analyzed, concentrations of chromium exceeded the regulatory levels in only 3 samples, 1 each from the Edgemoor, New Johnsonville, and Henderson facilities. Chromium was present at concentrations in excess of the regulatory level by a factor ranging from 1.1 to 20. Lead concentrations exceeded the regulatory level in just 1 sample (from the Henderson facility) by a factor of 6.3. At one facility for which comparable SPLP test data are available, lead and chromium concentrations as determined by SPLP analyses also exceeded the EP toxicity regulatory levels by roughly the same margins as the EP test results.

The waste management practice used at titanium tetrachloride production facilities to manage chloride process waste solids is treatment of the stream as generated (i.e., in a slurry) and disposal of the solid residual (i.e., the special waste).

13.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proved. Overall conclusions about the hazards associated with the waste solids are provided after these two study factors are discussed.

13.3.1 Risks Associated With Chloride Process Waste Solids

Any potential danger to human health and the environment from chloride process waste solids depends on the composition of the waste, the management practices that are used, and the environmental settings of the facilities where the waste solids are generated and managed.

Constituents of Concern

EPA identified chemical constituents in chloride process waste solids (as managed) that may present a hazard by collecting data on the composition of the solids and evaluating the intrinsic hazard of the chemical constituents.

Data on Chloride Process Waste Solids Composition

EPA's characterization of chloride process waste solids and leachate is based on data from two sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); and (2) industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 21 metals, chloride, fluoride, sulfate, and 3 radionuclides (radium-226, thorium-232, and uranium-238) in total and/or leach test analyses, and represent samples from 6 facilities.

Concentrations in samples of the chloride process waste solids are consistent for most constituents across all data sources and facilities. Arsenic concentrations in the solids, however, vary over five orders of magnitude across the facilities. Chemical concentrations in the waste solids leachate are generally consistent across the data sources, types of leach tests (i.e., EP and SPLP), and facilities.

Process for Identifying Constituents of Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the data summarized above to determine if chloride process waste solids or leachate from the solids contain any chemical constituents that are intrinsically hazardous, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing the concentrations of chemical constituents to screening criteria that reflect the potential for hazards, and then by evaluating the environmental persistence and mobility of any constituents present in concentrations above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which the waste solid constituents are released and migrate through the environment to possible exposure points. As a result, this process identifies and eliminates from further consideration only those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic organisms, and water quality (see Exhibit 2-3). Given the conservative (i.e., protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste solids in greater detail.

Identified Constituents of Concern

Exhibits 13-3 and 13-4 summarize the frequency with which the chemical and radioactive constituents of the chloride process waste solids and leachate exceed the risk screening criteria. Data are provided in the exhibits for all constituents that are present in concentrations that exceed a screening criterion.

Exhibit 13-3 identifies constituents in the waste solids that, based on total sample analysis results, were detected in concentrations above the screening criteria. Only 5 of the 28 constituents analyzed in the waste solids exceed the screening criteria: arsenic, chromium, radium-226, thorium-232, and uranium-238. Of these constituents, chromium and radium-226 exceed the screening criteria most frequently, in at least 83 percent of all samples analyzed and at all facilities for which data are available. Chromium concentrations exceed the screening criteria by the widest margin, by as much as a factor of 75. Radium-226 levels as high as 24.5 pCi/g (5 times the screening criterion) were measured. In addition, maximum concentrations of 43 pCi/g of uranium-238 and 89 pCi/g thorium-232 exceed the screening criteria by factors of 4.3 and 8.9, respectively.[13] The other constituents exceed the screening criteria by a factor of 15 or less. These exceedances indicate the potential for several types of impacts, as follows:

- Chromium, arsenic, thorium-232, and uranium-238 concentrations in the waste solids may pose a cancer risk of greater than $1x10^{-5}$ if dust from the solids is blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter. As discussed in more detail in the next section, there is a moderate potential for dust to be blown into the air at the four facilities that manage the waste solids in waste piles and landfills.

Exhibit 13-3
Potential Constituents of Concern in Titanium Chloride Process Waste Solids[(a)]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria[(b)]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Chromium	14 / 14	Inhalation*	14 / 14	6 / 6
Thorium-232	12 / 12	Inhalation* Radiation*[(c)]	1 / 12 1 / 12	1 / 1 1 / 1
Uranium-238	12 / 12	Inhalation* Radiation*[(c)]	1 / 12 2 / 12	1 / 1 1 / 1
Radium-226	12 / 12	Radiation*[(c)]	10 / 12	1 / 1
Arsenic	3 / 8	Ingestion* Inhalation*	2 / 8 2 / 8	1 / 6 1 / 6

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The screening criteria values used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

(c) Includes direct radiation from contaminated land and inhalation of radon decay products.

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[13] These radionuclide concentrations are similar to those reported in other sources. Specifically, "old sludge" from a titanium-chlorination process is reported to have 57 pCi/g uranium-238, 77 pCi/g thorium-232, and 25 pCi/gm radium-226 in Report No. 2 Natural Radioactivity Contamination Problems, Conference of Radiation Control Program Directors, Inc., August, 1981.

Exhibit 13-4
Potential Constituents of Concern in Titanium Chloride Waste Solids Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Iron	3 / 3	Resource Damage	3 / 3	3 / 3
		Aquatic Damage	2 / 3	2 / 3
Radium-226	2 / 2	Human Health*	2 / 2	1 / 1
Manganese[c]	4 / 4	Human Health	1 / 4	1 / 4
		Resource Damage	4 / 4	4 / 4
Chromium	8 / 16	Human Health	4 / 16	3 / 6
		Resource Damage	7 / 16	5 / 6
		Aquatic Ecological	5 / 16	5 / 6
Lead	5 / 16	Human Health	4 / 16	4 / 6
		Resource Damage	5 / 16	5 / 6
		Aquatic Ecological	4 / 16	4 / 6
Aluminum	3 / 3	Resource Damage	1 / 3	1 / 3
		Aquatic Ecological	2 / 3	2 / 3
Molybdenum	2 / 3	Resource Damage	2 /3	2 / 3
Copper	2 / 3	Aquatic Ecological	2 / 3	2 / 3
Vanadium	3 / 4	Human Health	1 / 4	1 / 4
		Resource Damage	2 / 4	2 / 4
		Aquatic Ecological	1 / 4	1 / 4
Arsenic[c]	1 / 5	Human Health*	1 / 5	1 / 4
		Resource Damage	1 / 5	1 / 4
Silver[c]	1 / 4	Human Health	1 / 4	1 / 4
		Resource Damage	1 / 4	1 / 4
		Aquatic Ecological	1 / 4	1 / 4
Nickel	3 / 4	Human Health	1 / 4	1 / 4
		Resource Damage	1 / 4	1 / 4
		Aquatic Ecological	1 / 4	1 / 4
Thallium[c]	1 / 4	Human Health	1 / 4	1 / 4
Antimony	1 / 3	Human Health	1 / 3	1 / 3
Selenium[c]	1 / 5	Resource Damage	1 / 5	1 / 4
		Aquatic Ecological	1 / 5	1 / 4
Cobalt[c]	1 / 4	Resource Damage	1 / 4	1 / 4

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The screening criteria values used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP leach test results.

- Arsenic concentrations in the waste solids could pose a cancer risk of more than 1×10^{-5} if a small quantity of the solids is incidentally ingested on a routine basis (which could occur if access to closed waste management units is not restricted or if the solids are used off-site in an unrestricted manner that allows children to come into direct contact with the waste).

- The concentrations of thorium-232, uranium-238, radium-226, (which were analyzed for in samples from only one facility) and other members of the uranium and thorium decay chains could pose a radiation hazard if the waste solids are allowed to be used in an unrestricted manner. For example, direct radiation doses and doses from the inhalation of radon decay products could be unacceptably high if the solids were to be used as fill material around homes.

Of the 25 constituents analyzed in the waste solids leachate, 16 were present in concentrations that exceed the screening criteria (see Exhibit 13-4). Among these constituents, chromium, copper, iron, lead, radium-226, manganese, and molybdenum concentrations in the leachate exceed the screening criteria most frequently and at the greatest number of facilities. Constituents present in concentrations that exceed the screening criteria by a factor of 10 or more include: aluminum, arsenic, chromium, iron, lead, manganese, molybdenum, nickel, vanadium, silver, and thallium. Measured concentrations of arsenic, chromium, iron, lead, manganese, vanadium, and silver also occasionally exceed the screening criteria by a factor of 100 or more. Lead concentrations in the leachate exceed the screening criteria by the widest margin (up to a factor of 625), and as discussed in section 13.2, lead and chromium were measured in concentrations that exceed the EP toxicity regulatory levels. These exceedances indicate the potential for the following types of impacts under the following conditions:

- Concentrations of arsenic, antimony, chromium, lead, manganese, nickel, radium-226, vanadium, silver, and thallium in the leachate exceed the human health screening criteria. This means that if the leachate migrates to drinking water sources with less than ten-fold dilution, long-term ingestion of untreated drinking water may cause adverse health effects. The diluted arsenic and radium-226 concentrations may cause a cancer risk of more than 1×10^{-5}.

- If the leachate migrates to surface or ground water with less than ten-fold dilution, the resulting concentrations of several constituents could render the water unsuitable for certain uses without prior treatment (i.e., cause water resource damages). Specifically, the diluted concentrations of arsenic, chromium, iron, lead, manganese, selenium, and silver may exceed the drinking water maximum contaminant levels, rendering the water unfit for human consumption. The diluted concentrations of aluminum, cobalt, molybdenum, nickel, and vanadium may exceed irrigation guidelines, rendering the water less desirable for use for agricultural purposes.

- Concentrations of aluminum, chromium, copper, iron, lead, nickel, selenium, silver, and vanadium in the leachate may present a threat to aquatic organisms if the leachate migrates (with less than 100-fold dilution) to surface waters.

These exceedances do not prove that the waste solids pose risk to human health and the environment, but rather indicate that the solids may present a hazard under very conservative, hypothetical exposure conditions. To examine the hazards associated with this waste in greater detail, the Agency proceeded to the next step of the risk analysis evaluate the actual release, transport, and exposure conditions at the plants that actively generate and manage the waste solids.

Release, Transport, and Exposure Potential

The following analysis considers the baseline hazards of the waste as it was generated and managed at the nine titanium tetrachloride producing facilities in 1988. This evaluation does not assess the hazards of off-site use or disposal of the waste solids because the solids are never utilized managed off-site (nor are they likely to be in the near future). In addition, the analysis does not consider the risks associated with potential future changes in waste management practices or population patterns, because of a lack of adequate information on possible future conditions.

Ground-Water Release, Transport, and Exposure Potential

EPA and industry test data show that several constituents are capable of leaching from the chloride process waste solids in concentrations above the screening criteria. Given the low-pH conditions that are expected to exist, a large number of these constituents will be relatively mobile in ground water, including antimony, arsenic, chromium, copper, cobalt, iron, lead, manganese, nickel, selenium, silver, and thallium. Of these constituents, arsenic, chromium, iron, lead, manganese, and silver pose the greatest potential ground-water threat, considering their concentrations in the leachate relative to the screening criteria. Key factors that influence the potential for these constituents to cause ground-water impacts at each facility are summarized in Exhibit 13-5.

The waste solids are managed in surface impoundments and/or settling ponds at the eight facilities that did not declare their management techniques as confidential. These eight facilities are located in Antioch, CA, Edgemoor, DE, Hamilton, MS, Ashtabula, OH, New Johnsonville, TN, Pass Christian, MS, Henderson, NV, and Savannah, GA. At these sites, the waste solids are discharged as a slurry to the impoundments, where they settle to the bottom as a sludge. The standing liquid that is held on top of the settled solids provides a force that may drive contaminants from the solids to the subsurface. In this situation, the potential for release depends on the design features of the impoundments, the depth to ground water, and the permeability of the earth materials beneath the impoundments; the potential for exposure to contamination (if it occurs) depends on the surrounding ground-water use patterns. Considering these factors, which are summarized on a site-specific basis in Exhibit 13-5, the eight sites with impoundments can be grouped into three categories:

- There is a relatively high potential for ground-water contamination and subsequent exposure at the Hamilton facility. There are no known controls (e.g., liner or leachate collection systems) on the impoundments, the ground water is moderately shallow (roughly 6 meters deep), the substrate beneath the impoundments is a permeable sand, and there appears to be a drinking water well within 700 meters downgradient. This well, however, is on the opposite side of McKinley Creek from the impoundments, and thus may not receive full contaminant loadings from the impoundments (due to ground-water discharge to the creek).

- The potential for ground-water release and exposure is moderate at the Ashtabula and Savannah facilities. At Ashtabula, the on-site impoundment is underlain by in-situ clay and recompacted local clay, the ground water is moderately shallow (6 meters deep), the subsurface is mainly impermeable silt and clay, and the nearest downgradient drinking water well is roughly 800 meters away. Although the impoundment at Savannah is equipped with a leachate collection system, the ground water is shallow (3 meters deep), the subsurface is mainly a permeable sand, and there appears to be a drinking water well within 200 meters downgradient.

- The potential for release to ground water is relatively high at the Antioch facility, but the potential for exposure to any ground-water contamination appears low. There are no known controls on the on-site impoundments, the ground water is very shallow (1 meter deep), and the subsurface is a permeable sand. However, the aquifer does not contain freshwater and does not appear to be used in the area.

- The potential for ground-water release and exposure at the facilities in Edgemoor, New Johnsonville, Pass Christian, and Henderson appears relatively low. At these facilities, the impoundments are equipped with either in-situ clay, recompacted clay, or, as is the case at Henderson, synthetic liners. The depth to useable ground water ranges from 6 to 48 meters, the underlying earth materials are generally sandy, and there are no known uses of the ground water within 1.6 km (1 mile).

Exhibit 13-5
Summary of Release, Transport, and Exposure Potential for Chloride Process Waste Solids

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
ANTIOCH	**Ground water**: No information on the engineered controls for small on-site settling pond, but because of the relatively permeable subsurface (90% sand), releases to the very shallow aquifer (0.6 to 1.2 meters) are possible. Exposures unlikely because the aquifer does not contain fresh water and is not used in the area. **Surface water**: Moderate annual precipitation (41 cm/year) and gently sloped land (0-2%) limit potential for storm water to cause overflowing from the settling pond. Migration of contaminants to San Joaquin River (located 920 meters away) via recharge to ground water could occur; potential for ecological impacts and resource damage is low due to the large assimilative capacity (5,000 mgd) of the river; moderate potential for current human health risks because there is an intake for drinking water located within 100 meters downstream of the facility. **Air**: Releases unlikely because waste solids remain submerged beneath liquid.	Located within 1.6 km of a wetland and within 2.6 km of an endangered species habitat
EDGEMOOR	**Ground water**: Releases limited by recompacted local clay liners. Even if releases to shallow ground water (6 meters) occur, there are no users of the ground water within 1.6 km downgradient. **Surface water**: Routine overland releases limited by stormwater run-on/run-off controls; because of high precipitation ([illegible] cm/year), the steep topographic slope (6 to 12%), and possible floods (facility located in 100-year floodplain), episodic overflow and overland runoff could occur. The Delaware River is located very close (10 meters) from the boundary of the facility, but is not used as a source of drinking water within 24 km downstream. **Air**: Releases unlikely because wastes solids remain submerged beneath liquid.	Located in a 100-year floodplain
NEW JOHNSONVILLE	**Ground water**: Five surface impoundments are underlain by recompacted local clay while the single landfill is not lined. Although there is relatively high precipitation (126 cm/yr) and recharge (28 cm/yr), significant releases to ground water unlikely because water table is moderately deep (11 m) and useable ground water is even deeper (49 m). No known users of the aquifer within 1.6 km. **Surface water**: Although there is high precipitation in the area, potential for erosion from the landfill and overflow from the surface impoundments is limited by moderate topographic slope (2-6%) and stormwater run-on/run-off controls; releases via recharge to ground water could occur to the Tennessee River located 30 meters away, but its very large flow (42,000 mgd) yields significant dilution capacity; there is a downstream drinking water intake supplying approximately 400 people. **Air**: Releases from landfill not controlled by dust suppression; small number of wet days (98 days/year) and average wind speeds up to 3.4 m/s could lead to airborne dust. There are no residences within 1.6 km of the facility.	Located within 1 mile of a National Park

Exhibit 13-5 (cont'd)
Summary of Release, Transport, and Exposure Potential for Chloride Process Waste Solids

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
PASS CHRISTIAN	Ground water: Although two surface impoundments, one settling pond, and one landfill are underlain by recompacted clay, releases may occur due to the high precipitation (160 cm/year), moderate net recharge (15 cm/year), and shallow water table (2 meters); however, the useable aquifer is deep (26 m) and there are no drinking water wells within 1.6 km downgradient of the facility. Surface water: Although facility is located in high precipitation area, overland runoff limited by stormwater run-on/run-off controls and gentle topographic slope (0-2%). Contaminants could migrate to the St. Louis Bay (274 meters away) via recharge to shallow ground water (2 meters deep). Air: Releases from landfill not controlled by dust suppression; small number of wet days (92 days/year) and average wind speeds up to 4.2 m/s could lead to airborne dust and inhalation exposures at closest residence 60 meters from the facility, as well as potential food chain exposures through deposition of particulates on agricultural fields within 1.6 km; a total of 30 people live within 1.6 km.	Located in a 100-year floodplain and within 1.6 km of a wetland
SAVANNAH	Ground water: Surface impoundment is equipped with leachate collection system, but is without a liner; waste pile is without any ground-water controls; potential for releases to ground water because of high precipitation (126 cm/year), moderate [illegible] recharge (15.3 cm/year), permeable subsurface (85% sand), and shallow useable aquifer (3 meters). Potential drinking water exposure could occur at municipal well 183 meters downgradient. Surface water: Overland run-off limited by stormwater run-on/run-off controls at both management units, and gentle topographic slope (0-2%). Contaminants could migrate to nearby Savannah River (90 meters) via ground-water recharge; no consumptive uses of the river within 24 km, and releases to surface water pose low aquatic ecological risks (because of the river's large dilution capacity, i.e., 8,000 mgd). Air: Air releases not controlled by dust suppression; moderate number of wet days (111 days/year), average wind speeds up to 3.4 m/s, and low height of waste pile (1.2 meters) may limit airborne dust to an extent; potential inhalation exposures could occur at closest residence within 100 meters of the facility.	Located within 1.6 km of a wetland and the Savannah National Wildlife Refuge
HAMILTON	Ground water: Releases from two large impoundments to the shallow usable aquifer (6 meters) could occur because of the fairly permeable subsurface (93% sand) and moderate net recharge (13 cm/year); impoundments border McKinley Creek and ground water may discharge directly into the creek without being used; however, if ground water passes beneath the creek, a well 700 meters downgradient may become contaminated. Surface water: Overland release from the impoundments is limited by stormwater run-on/run-off controls, and gentle topographic slope (0-2%); releases to nearby McKinley Creek (60 meters) could occur by recharge from ground water; low potential for human health or ecological risks because of the large flow of the creek (5,000 mgd); a drinking water intake exists 1,700 meters downstream. Air: Releases unlikely because waste solids remain submerged beneath liquid.	Located within 1.6 km of a wetland

Exhibit 13-5 (cont'd)
Summary of Release, Transport, and Exposure Potential for Chloride Process Waste Solids

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
ASHTABULA	Ground water: Two surface impoundments are underlain by in-situ clay and recompacted local clay that could prevent releases to ground water; if releases were to occur to the shallow aquifer (6 meters), potential drinking water exposures could occur at municipal well 800 meters downgradient. Surface water: Overland releases from the impoundments are limited by stormwater run-on/run-off controls and gentle topographic slope (0-2%); releases to nearby Lake Erie (700 meters) could occur by recharge to ground water; releases to the lake should be diluted significantly. Air: Releases unlikely because waste solids remain submerged beneath liquid.	Located in a fault zone
BALTIMORE	Ground water: All specifications on the two management units are confidential; moderately shallow ground water (9 m) brackish and not used; useable aquifer at 137 m protected by clay confining layer; no consumptive uses of the aquifer within 1.6 km of the facility. Surface water: No information on controls to prevent overland run-off, but potential for run-off could be significant because of high precipitation and relatively impermeable subsurface; migration of contaminants via recharge to shallow ground water that discharges to the closest surface water, i.e., Chesapeake Bay ([illegible]90 meters) could occur. Air: Moderate number of wet days (103 days/year) could limit airborne releases to an extent; if the high wind speeds (average wind speeds up to 5.3 m/s) lead to airborne dust, potential exposures would be minimal because there are no residences within 1.6 km of the facility.	Located within 1.6 km of a wetland
HENDERSON	Ground water: Surface impoundment has a synthetic liner but waste pile has no ground-water controls; depth to useable aquifer is not known but releases are limited by low precipitation (11 cm/year), and zero net recharge; no drinking water wells within 1.6 km downgradient. Surface water: Overland run-off limited by stormwater run-on/run-off controls, gentle topographic slope (2-6%), and low annual precipitation; nevertheless, the facility is located in a 100-year floodplain and episodic release could occur in a flood event. A lake (Las Vegas Wash) is located just 46 meters from the facility and potential human health exposures could occur at a drinking water intake 1100 meters from the facility. Air: Releases not controlled by dust suppression; very small number of wet days (21 days/year), height of waste pile (6 meters), and average wind speeds into 4.1 m/s could lead to airborne dust and inhalation exposures at closest resident 90 meters from the facility. Population within 1.6 km of the facility is 5,000.	Located in a 100-year floodplain, and within 1.6 km of an wetland and the Lake Mead National Recreation Area

The four facilities located in New Johnsonville, TN, Pass Christian, MS, Henderson, NV, and Savannah, GA periodically dredge solids from the impoundments described above and place the dried solids in on-site landfills or waste piles. In general, the potential for contaminants to leach from these units into ground water is significantly lower than the potential for release from the impoundments. In waste piles or landfills, the hydraulic head that may force contaminants out of the impoundments has been removed and the potential for release is limited by the amount of rainfall that is able to infiltrate through the pile or landfill and into the ground. Considering the site-specific factors summarized in Exhibit 13-5:

- There is a moderate potential for release from the waste pile and landfill at the Savannah and Pass Christian facilities. At both sites, the waste management unit is not lined, net recharge is moderate (15 cm/yr), and ground water is shallow (2 to 3 meters deep). There also appears to be a drinking water well within 200 meters downgradient of the Savannah facility. The useable aquifer at Pass Christian is 26 meters deep, and there appears to be no downgradient wells that withdraw water from this aquifer within 1.6 km (1 mile).
- The potential for significant releases from the piles/landfills at the New Johnsonville and Henderson facilities is low. Although the net infiltration of water into the ground at New Johnsonville is moderate (28 cm/year), the ground water is relatively deep (11 m to the water table and 48 meters to a useable aquifer) and contaminants leaching from the landfill at this site will likely be predominantly bound up in the soil in the unsaturated zone. The Henderson facility is located in a very arid area with low precipitation (around 11 cm/yr) and essentially no net recharge. Therefore, there is virtually no water available to seep through the pile at this site and carry contaminants to the subsurface.

The type and characteristics of the waste management unit(s) at the facility in Baltimore, MD are confidential. However, based on the depth to useable ground water[14] (137 meters), impermeable subsurface (70% clay), and current aquifer-use patterns in the vicinity of this facility (virtually all water is provided by the city water supply, the sources of which are several distant reservoirs), the potential for release to potable ground water and subsequent human exposure appears minimal.

Surface Water Release, Transport, and Exposure Potential

In theory, contaminants from chloride process waste solids could enter surface waters by two main pathways: (1) migration of leachate through ground water that discharges to surface water; and (2) direct overland (stormwater) run-off in either a dissolved form or in the form of solid particles. Based on the available data on the waste solids composition, the solids contain a number of constituents in concentrations that are above the screening criteria. Site-specific factors that influence the potential for these contaminants to migrate to surface waters are summarized in Exhibit 13-5.

Direct overland run-off of the waste contaminants when managed in surface impoundments is limited to a large extent by run-on/run-off controls at each site, and appears possible only in the event of a flood at the Edgemoor, Pass Christian, and Henderson facilities (which are located in 100-year floodplains). It is more likely that waste solids contaminants managed in surface impoundments might migrate to surface water by leaching into ground water that discharges to surface water. Considering the ground-water release potential (as discussed in the section above) and the proximity of the plants to surface waters, the potential for release of waste solids contaminants from impoundments to surface water appears greatest at the Antioch, Hamilton, Ashtabula, Edgemoor, and Savannah facilities. The distances between these facilities and the nearest surface water bodies ranges from 10 to 880 meters. However, all of these water bodies are very large and have flows capable of readily diluting small contaminant loads from ground water (e.g., the annual average flows of rivers nearest the Antioch, Hamilton, and Savannah facilities are 5,000 mgd or greater, and the Ashtabula facility is adjacent to Lake Erie). Therefore, based on all of these factors, there is a minimal potential for the solids to cause significant surface water impacts when managed in surface impoundments.

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[14] There is a shallow aquifer less than 10 meters from the surface, but due to salt water intrusion, this aquifer is no longer suitable for use as a water supply.

When managed in piles and landfills, the waste solids are more likely to migrate into surface waters via stormwater erosion (as discussed in the preceding section, there is only a moderate potential for contaminants to seep into ground water from these units, and this potential exists at only two facilities). The physical form of the waste solids should not limit the erosion and subsequent entrainment of solids in run-off. Particles that are 0.1 mm or less in size tend to be appreciably erodible, and a large fraction of the waste solids are expected to be in this size range (chloride process waste solids particles are typically on the order of 0.02 mm in diameter). Again, only the New Johnsonville, Pass Christian, Henderson, and Savannah facilities manage the waste solids in piles or landfills. The potential for waste solids contaminants from these sites to cause significant surface water impacts is limited by several factors, as summarized below:

- Although the New Johnsonville and Savannah facilities are located in areas with high precipitation (126 cm/year), routine overland runoff from the on-site waste pile and landfill is limited by stormwater run-on/run-off controls and moderately gentle slopes (less than 6 percent). Moreover, the potential for surface water damages is low because the Tennessee and Savannah Rivers located within 100 meters of the facilities have large capacities to assimilate contaminant inflows (i.e., average flows of 42,000 and 8,000 mgd, respectively).
- Although the Pass Christian facility is only 30 meters from the St. Louis Bay, routine releases to the bay from the on-site landfill via either ground-water discharge or stormwater erosion are likely to be readily assimilated in the bay's large flow.
- Routine overland releases are limited at the Henderson facility by stormwater run-on/run-off controls, and the low precipitation (11 cm/year) and gentle topographic slope (0-2 percent) in the area. However, the facility is located in a 100-year floodplain and is only 45 meters from a lake (Las Vegas Wash). Episodic overland run-off of contaminants from the waste solids to the lake is possible in the unlikely event of a flood. Any contaminants reaching the lake in this manner, if not sufficiently diluted, could endanger aquatic life, restrict potential future uses of the lake, and pose a current health risk via a drinking water intake 1,100 meters from the facility.

At the facility in Baltimore, MD, it is possible for contaminants to leach into the shallow ground water located 9 meters below the surface and migrate into the Chesapeake Bay located 500 meters downgradient. Because the precipitation in this area is high (108 cm) and the subsurface is relatively impermeable, overland run-off due to surface erosion is also possible at this facility. If contaminants did reach the bay via either of these routes, they would likely be rapidly diluted by the bay's large flow.

Air Release, Transport, and Exposure Potential

Only windblown dust particles from the chloride process waste solids are of concern for the air pathway because all hazardous constituents of the waste are nonvolatile inorganics. The potential for dust to be blown into the air from the surface impoundments and solids settling ponds is virtually non-existent because the waste solids are submerged beneath liquids. When the settled solids and sludge are dredged, dried, and accumulated in waste piles or landfills, airborne dust releases from these units could be possible. If releases were to occur, chromium, and to a lesser extent, arsenic, thorium-232, and uranium-238 in the waste solids particles could cause adverse health effects if inhaled, depending on the amount of dust emitted and the proximity of receptors.

Release of dust particles from the landfills and waste piles to the air is possible because the waste solids can be 20 micrometers (μm) or less in diameter (smaller than sand). In general, particles that are $\leq$ 100 μm in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 μm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 μm in diameter are respirable. Therefore, a significant amount of the waste solids are expected to be suspendable and transportable, and a small fraction is expected to be respirable.

For the chloride process waste solids accumulated in waste piles and landfills, site-specific factors affecting the potential for airborne release and exposure include the exposed or uncovered surface area of the units, wind speeds, number of days with precipitation (which affects the moisture content of the waste solids), the use of dust suppression controls, and the proximity of the units to potentially exposed populations. These factors are summarized on a site-specific basis in Exhibit 13-5 for the four facilities that manage the solids in waste piles and landfills (New Johnsonville, Pass Christian, Savannah, and Henderson).

Considering these factors at the two sites with landfills, located in New Johnsonville, TN and Pass Christian, MS, airborne releases of dust are considered possible at both sites, but it appears that people could be exposed to such releases at only the Pass Christian facility. Neither facility practices dust suppression and the number of days with rain, which suppresses dust naturally, is small at both facilities (92 and 98 days/yr). As a result, the exposed surface of the waste solids is expected to be dry most of the time. It is not known if inactive portions of the landfill are covered, but active portions are certainly uncovered and exposed to the wind. Although there are short term gusts of stronger winds, average wind speeds range up to 3.4 and 4.2 m/s at these facilities, which are strong enough to suspend the fine fraction of the solids. If such releases occur, the potential for inhalation exposures could be significant at the Pass Christian facility because there is at least one residence within a distance of 60 meters. However, the population within a mile of the facility is small (30 people). Furthermore, at the Pass Christian facility, there is also a potential for food chain exposures through deposition of particles on food crops in the agricultural fields within a mile of the facility. There is no known population within a mile of the New Johnsonville facility.

At the two facilities that manage the waste solids in piles, the potential for airborne releases and exposures is high at the Henderson, NV facility and moderate at the Savannah, GA facility, based on the following factors:

- At the Henderson facility, the waste solids pile covers 1.5 acres, is 6 meters high, and is assumed to be uncovered. The waste solids in the pile are probably dry most of the time because no dust suppression is conducted and the number of days with precipitation is very small (21 days/yr). Average wind speeds at the facility range up to 4.1 m/s, although there are certainly short-term gusts of stronger winds. If significant quantities of dust are blown into the air, inhalation exposures could occur at the nearest residence, located only 90 meters from the facility. The total population within 1.6 km (1 mile) is 5,000.
- The waste solids pile at the Savannah facility covers an area of 1.5 hectares (3.7 acres), is 1.2 meters high, and is assumed to be uncovered. Although the facility does not practice dust suppression, there is a moderate number of days with rain (111 days/year) that should help keep the surface of the waste solids moist part of the time. Annual average wind-speeds range up to 3.4 m/s, which is sufficient to cause wind erosion of fine particles. If released, the wind-blown dust could lead to inhalation exposures at the closest residence (400 meters from the facility), as well as exposures to the 500 people that live within 1.6 km (1 mile).

Proximity to Sensitive Environments

As summarized in Exhibit 13-5, all nine titanium tetrachloride/dioxide facilities are located in environments that are either vulnerable to contamination or have high resource value that may warrant special consideration. In particular:

- The Antioch facility is located within 2.6 km (1.6 miles) of the critical habitat of an endangered species, the Antioch Dunes Evening Primrose. Based on the conditions at this site, the titanium waste solids at the Antioch facility could conceivably be a source of ground-water contamination, but are not likely to be a significant source of surface water or air contamination (see the preceding analysis). Considering the distance between the site and the critical habitat, the waste solids should not pose a significant hazard to the endangered species.

- The Edgemoor, Henderson, and Pass Christian facilities are located in 100-year floodplains, which creates the potential for large, episodic releases of the waste solids in the unlikely event of a large flood.
- The Henderson, Antioch, Hamilton, Baltimore, and Savannah facilities are located within 1.6 km (one mile) of wetlands (defined here to include swamps, marshes, bogs, and other similar areas). Wetlands are commonly entitled to special protection because they create habitats for many forms of wildlife, purify natural water, provide flood and storm damage protection, and afford a number of other benefits. Contamination from titanium wastes produced at these sites could potentially cause adverse effects in adjacent wetlands.
- The Ashtabula facility is located in a fault zone. Although unlikely, there is some potential for earthquake damage to the in-situ and recompacted clay liner of the on-site surface impoundment, potentially allowing greater-than-expected releases of waste solids contaminants to the subsurface.
- The New Johnsonville facility is located within 1.6 km (one mile) of a National Park. Based on the preceding analysis of the release, transport, and exposure potential of this facility, it is possible for waste solids contaminants to be blown into the air as dust from the on-site landfill (the potential for significant releases to ground water and surface water appears to be low). Any windblown contaminants produced from this landfill could potentially cause adverse effects on the habitats and resources provided by the National Park.
- The Savannah facility is located within 1.6 km (one mile) of a National Wildlife Refuge. Based on the preceding analysis of potential release, transport, and exposure pathways, there is a moderate potential for releases of waste solids contaminants from this site to ground water, surface water, and air. Any contaminants released from this site could potentially cause adverse effects on the habitats and resources provided by the National Wildlife Refuge.
- The Henderson facility is located within 1.6 km (one mile) of a National Recreation Area. As discussed in the preceding section, the primary potential release pathway at this facility is windblown dust from the on-site waste pile. Any airborne contaminants released from this waste pile could conceivably cause adverse effects on the habitats and resources provided by the National Recreation Area.

Risk Modeling

Based on the preceding analysis of the intrinsic hazard of chloride process waste solids and the potential for contaminants from the solids to be released into the environment, EPA ranked the waste solids as having a relatively high potential at some facilities to cause human health and environmental risks (compared to the other mineral processing wastes studied in this report). Therefore, the Agency used the model "Multimedia Soils" (MMSOILS) to estimate ground-water, surface water, and air risks caused by the existing waste solids management practices. Rather than model all nine facilities that currently generate and manage the solids, EPA modeled only those facilities and release/exposure pathways that appear to pose the greatest concern in order to develop reasonable upper bound estimates of the risks across the industry.

Ground-Water Risks

EPA modeled potential releases to ground water from the surface impoundments used to accumulate waste solids at the Kerr-McGee facility in Hamilton, MS. This facility was selected for ground-water modeling because it appears to have the highest ground-water release and exposure potential of all the active titanium tetrachloride facilities, based on the above analysis of management practice and environmental setting characteristics. Using median contaminant concentrations measured in waste solids from the other titanium facilities,[15] combined with site-specific data with respect to waste solid quantities, impoundment design features, and hydrogeologic characteristics at the Hamilton facility, EPA predicted the concentrations of nine constituents (arsenic, chromium, cobalt, copper, iron, lead, manganese, nickel, and silver) at a variety of downgradient locations. The downgradient distances that were modeled included the property boundary and nearest surface water body (60 meters), the nearest existing residence that could have a drinking water well (700 meters), and, to analyze how far the contaminant plume might migrate, a distance of 1,000 meters. For each constituent, the Agency compared the predicted concentrations at these locations to cancer risk levels, threshold concentrations for noncancer effects, drinking water maximum contaminant levels (MCLs), and guidelines for irrigation and livestock waters recommended by the National Academy of Sciences (NAS).

For all of the constituents except arsenic and cobalt, the predicted concentrations at each of the downgradient distances modeled (including the property boundary roughly 60 meters downgradient) were at least two orders of magnitude below the various criteria. The predicted concentration of arsenic at the property boundary poses a lifetime cancer risk of 3x10^{-4} (i.e., the chance of getting cancer would be approximately 3 in 10,000 if the water was ingested over a 70-year lifetime). This predicted arsenic concentration, however, is only 0.2 times the MCL. It is unlikely that anyone would actually drink the ground water at or very near the property boundary at this facility because the impoundments border McKinley Creek, and it is unlikely that anyone would place a drinking water well between the impoundments and McKinley Creek. The nearest existing residence that conceivably could have a drinking water well is located about 700 meters downgradient. Assuming that the ground water leaving the Hamilton site migrates beneath McKinley Creek and eventually to this residence, rather than discharging directly into the creek, the concentration of arsenic at this distant location would pose a very low lifetime cancer risk, less than 1x10^{-10}.

The predicted concentration of cobalt did not exceed any of the criteria at any of the downgradient distances, but it was equal to 0.8 times the NAS guideline for irrigation water at the property boundary. Concentrations of cobalt in excess of this guideline have been shown to be toxic to a variety of plants, including tomatoes, peas, beans, oats, rye, wheat, barley, and corn. Although the Hamilton site is located in an agricultural area, this cobalt contamination is not likely to cause significant impacts because: the maximum predicted concentration at a point where the ground water conceivably could be used is below the criterion, the contamination may discharge directly into McKinley Creek where it would be further diluted, and the predicted concentration of cobalt in ground water at the nearest downgradient residence that could have a well is more than two orders of magnitude below the NAS guideline.

As a "worst-case" analysis, EPA estimated the downgradient concentrations of chromium and lead assuming that the waste solids leachate from the impoundments at Hamilton contain the highest concentrations observed in any of the available sample results, 100 mg/l chromium and 31 mg/l lead. This chromium concentration exceeds the EP toxic level by a factor of 20 and the lead concentration exceeds the EP toxic level by a factor of 6. Even when these maximum leachate concentrations were used, the ground-water concentrations of both chromium and lead at the property boundary were predicted to be more than two orders of magnitude below their respective criteria.

Surface Water Risks

To evaluate surface water risks, EPA again considered the Kerr-McGee facility in Hamilton, MS. Having large impoundments within 60 meters of a creek, this facility has a relatively high potential (compared to the other eight titanium facilities) of contaminating surface water via releases to ground water. In order to assess the possible combined effect of stormwater erosion into surface water, the Agency conservatively assumed that, after closure, the impoundments were filled with waste solids but not covered or equipped with run-off controls.

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[15] No data are available on the composition of waste solids at the Hamilton facility.

Using this conservative scenario, EPA predicted the concentration of the following waste solid contaminants in McKinley Creek after they have been fully mixed in the creek's flow: arsenic, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, and thallium. For each constituent, the Agency compared the predicted concentrations to cancer risk levels, threshold concentrations for noncancer effects, drinking water MCLs, freshwater ambient water quality criteria, and the NAS recommended guidelines for irrigation and livestock. Note that the methodology used here does not account for removal of pollutants via drinking water treatment, and thus overstates the risk through that pathway.

Even with this conservative approach, EPA's risk model predicted that the average annual flow of McKinley Creek is capable of effectively assimilating the annual load of contaminants from the on-site impoundments. The predicted concentrations of all the constituents were more than two orders of magnitude below the various criteria. The predicted concentration of arsenic in the creek would pose a very low lifetime cancer risk, about $1x10^{-8}$, and is more than five orders of magnitude below the MCL. With the exception of arsenic and cobalt, essentially 100 percent of the contamination in McKinley Creek was predicted to be caused by the erosion of fine particles of the waste solids (seepage of contaminants into ground water with subsequent discharge into the creek resulted in a negligible pollutant loading). For arsenic and cobalt, approximately 80 percent of the contaminant load to the stream was through ground-water discharge, while only 20 percent was due to erosion.

As was done in the assessment of ground-water risks, EPA analyzed how these risk estimates would change if, instead of using median contaminant concentrations, the concentrations of chromium and lead in leachate from the impoundment were assumed to equal the maximum concentrations observed in EP leach tests (which exceeded the EP-toxic levels). Using these maximum concentrations would increase the loading of chromium to the creek, but not enough to make the surface water concentration approach hazardous levels. Similarly, increasing the lead concentration in the leachate had no effect on the predicted concentration in McKinley Creek because essentially all of the lead contamination was predicted to enter the creek by erosion rather than seepage through ground water.

None of the constituents that were modeled are recognized as having the potential to biomagnify (concentrate in the tissue of organisms higher in the food chain). Arsenic and chromium can bioaccumulate slightly in the tissue of freshwater fish that may be ingested by humans. However, even under worst-case exposure assumptions, the predicted concentrations of these contaminants are very unlikely to cause adverse health effects through the fish ingestion pathway.

Air Risks

To analyze air risks, EPA modeled the release of windblown dust from the waste solids pile and the associated inhalation risks at the facility in Henderson, NV. Of the nine active titanium facilities, this facility has the greatest potential to pose air risks because the solids are managed in a large pile that is uncovered, exposed to relatively high winds, and dry most of the time (as described in the above analysis of release, transport, and exposure potential). There is also a residence located just 90 meters downwind and 5,000 people live within one mile; all could be exposed to any windblown dust. Using the median constituent concentrations and site-specific data with respect to waste quantities, existing management practices, and atmospheric dispersion conditions, EPA estimated the release and inhalation risks of arsenic, chromium, thorium-232, and uranium-238, which are the primary constituents of concern through the air pathway, based on the preceding analysis of the waste solids' composition.

At the residence of the maximum exposed individual (roughly 90 meters downwind from the waste pile), EPA predicted airborne concentrations of arsenic, chromium, thorium-232, and uranium-238. Total lifetime cancer risk, from all four constituents combined, is $1x10^{-8}$. Most of this risk was estimated to be caused by chromium, conservatively assumed here to exist in its carcinogenic hexavalent form. If the maximum waste solids concentrations of these constituents were used in the model instead of median concentrations, the total lifetime cancer risk would be $2x10^{-7}$; this represents the maximum inhalation risk expected across the industry. The predicted concentrations of these contaminants 800 meters (0.5 mile) downwind in the predominant wind direction poses a lifetime cancer risk of $3x10^{-9}$. This risk approximates the average inhalation risk of the 5,000 people living within 1.6 km (1 mile) of the facility.

13.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the performance of waste management practices for chloride process waste solids from titanium tetrachloride production at the active titanium facilities, and at two inactive titanium facilities: Ormet in Albany, Oregon; and duPont in La Porte, Texas.[16] The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found no documented environmental damages clearly attributable to management of chloride process waste solids from titanium tetrachloride production at any of these facilities. Some cases of documented damage attributable to other wastes were identified, however, and it is possible, though not demonstrated, that waste solids have contributed to these observed damages.

13.3.3 Findings Concerning the Hazards of Chloride Process Waste Solids

Available data on the composition of the waste solids show that the solids contain over 17 constituents that are present in concentrations that exceed the screening criteria. The contaminants that appear to pose the greatest potential threat are arsenic, chromium, iron, lead, manganese, vanadium, and silver. Based on available data and professional judgment, EPA does not believe that the waste solids exhibit the hazardous waste characteristics of corrosivity, ignitability, or reactivity. However, using the EP leach test, chromium exceeded the EP toxicity regulatory level in 3 of 16 samples, and lead exceeded the EP toxicity regulatory level in 1 of 16 samples. Lead and chromium concentrations measured using the SPLP test also exceeded the EP toxicity regulatory levels, by roughly the same margin as the EP test results. In addition, the waste solids contain uranium-238, thorium-232, and their decay products in concentrations that could pose an unacceptably high radiation risk if the solids were allowed to be used in an unrestricted fashion.

Based on an examination of the characteristics of each site, EPA believes that there is a potential for waste solids contaminants to migrate into ground-water, surface water, and air at the active titanium facilities. For example:

- There is a relatively high potential for ground-water contamination from the impoundments at the Antioch, CA and Hamilton, MS facilities because the solids are submerged beneath liquids that could hydraulically force contaminants into the subsurface, some of the impoundments may not be equipped with liners or leachate collection systems, the ground water is shallow (1 to 6 m deep), and the subsurface is highly permeable.
- Most of the facilities are located within 100 meters of a river or creek. At those sites with a relatively high ground-water release potential, it is likely that any ground-water contamination would discharge directly into these water bodies. In addition, the particle size of the solids is fairly small and thus it is possible for contaminants to erode into nearby creeks and rivers when the solids are managed in landfills and waste piles.
- The small particle size of the solids is conducive to wind erosion and transport, and the solids are managed at four facilities in piles or landfills that are exposed to the wind. The potential for such airborne releases appears greatest at the waste solids pile at the Henderson, NV facility, where the solids are expected to remain dry most of the time and winds are relatively strong.

However, based on site-specific modeling results, the Agency predicts that the environmental contamination that could occur is not likely to cause significant adverse impacts, as currently managed at the existing facilities. This is corroborated by the lack of documented cases of damage attributable to the waste solids at the existing facilities. The environmental conditions at the Hamilton facility are most conducive to ground- and surface water contamination. Using these facility conditions as the basis for modeling, EPA predicts that the concentration of arsenic in ground water at the plant boundary (roughly 60 meters downgradient) could pose a lifetime cancer risk of $3x10^{-4}$. In terms of current exposures, however, nobody presently drinks the ground water at this location, and the predicted arsenic concentration at the nearest existing residence that could have a drinking water well would pose a cancer risk of less than $1x10^{-10}$. Any contamination of the water table aquifer at this site and any stormwater run-off are likely to discharge directly into adjacent McKinley Creek. The predicted annual average concentrations of arsenic and other contaminants in this creek are more than two orders of magnitude below various hazard criteria. EPA believes the ground-water and surface water risks at the other titanium facilities would be comparable if not lower than those predicted for the Hamilton facility.

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[16] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

At the Henderson, NV facility, EPA predicts a maximum lifetime cancer risk of $2x10^{-7}$ caused by the release and inhalation of windblown dust. Again, the inhalation risks at the other facilities are probably even lower.

13.4 Existing Federal and State Waste Management Controls

13.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations," which provide the basis for the minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT effluent limitation guidelines relevant to discharges from the production of titanium dioxide by oxidizing titanium tetrachloride include:

TITANIUM DIOXIDE-CHLORIDE PROCESS (40 CFR 415.222(b))		
Pollutant	**Daily Maximum**	**Monthly Average**
Total Suspended Solids	23 Kg/kkg	6.4 Kg/kkg
Total Chromium	0.057 Kg/kkg	0.030 Kg/kkg
pH	6 - 9	6 - 9

TITANIUM DIOXIDE-CHLORIDE-ILMENITE PROCESS (40 CFR 415.222(c))		
Pollutant	**Daily Maximum**	**Monthly Average**
Total Suspended Solids	35 Kg/kkg	9.6 Kg/kkg
Total Chromium	0.12 Kg/kkg	0.053 Kg/kkg
Total Nickel	0.072 Kg/kkg	0.035 Kg/kkg
pH	6 - 9	6 - 9

BAT effluent limitation guidelines for the above mentioned processes require that discharges not exceed the limitations set forth for chromium in 40 CFR 415.222 (b) and (c), and further that the discharge of nickel not exceed the levels established in 40 CFR 415.222 (c) for the dioxide-chloride-ilmenite process.

New source performance standards for these two processes include the following limitations (40 CFR 415.225 (b) and (c)):

TITANIUM DIOXIDE-CHLORIDE PROCESS

Pollutant	Daily Maximum	Monthly Average
Total Suspended Solids	14 Kg/kkg	4 Kg/kkg
Total Iron	0.52 Kg/kkg	0.016 Kg/kkg
Total Chromium	0.023 Kg/kkg	0.012 Kg/kkg
pH	6 - 9	6 - 9

TITANIUM DIOXIDE-CHLORIDE-ILMENITE PROCESS

Pollutant	Daily Maximum	Monthly Average
Total Suspended Solids	8.4 Kg/kkg	2.4 Kg/kkg
Total Iron	0.32 Kg/kkg	0.096 Kg/kkg
Total Chromium	0.014 Kg/kkg	0.0072 Kg/kkg
Total Nickel	0.020 Kg/kkg	.010 Kg/kkg
pH	6 - 9	6 - 9

13.4.2 State Regulation

The nine facilities in the titanium tetrachloride sector generating chloride process waste solids are located in eight states: California, Delaware, Georgia, Maryland, Mississippi, Nevada, Ohio, and Tennessee. For the purposes of this report, four of these states, Delaware, Mississippi, Ohio, and Tennessee, were studied in detail (see Chapter 2 for a discussion of the methodology used to select states for detailed regulatory study). Two facilities are located in Mississippi, while a single facility is located within each of the three remaining study states.

As a general overview, all of the eight states with titanium tetrachloride facilities except California exclude mineral processing wastes from their hazardous waste regulations. California has hazardous waste provisions for mine and mill tailings under certain circumstances, though it is not clear whether the state applies these provisions to the chloride process waste solids generated within its borders. Of the study states, Delaware, Tennessee, and Ohio have solid waste regulations that address and regulate the disposal of solid wastes from mineral processing, while Mississippi exempts on-site disposal of industrial solid waste from any requirements under the state's solid waste regulations. All four of the study states have approved NPDES programs and issue permits for all point-source discharges to surface waters. All four states also have air quality regulations, but none that are applicable to chloride process waste solids disposal practices.

Ohio and Tennessee each have a single titanium tetrachloride facility that generates chloride process waste solids.[17] The solid waste regulations of both of these states apply to mineral processing wastes.

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[17] Ohio's SCM facility at Ashtabula actually consists of two plants, Ashtabula I and II.

Because Ohio's regulations include exemptions for wastes that are reused or recycled, however, the state has not required a solid waste permit of the Ashtabula facility, which recycles all of its chloride process waste solids that are not shipped off-site for disposal. Ohio's regulations do not include specific storage requirements for non-putrescible wastes, regardless of the storage time before the waste is actually recycled. Similarly, although Tennessee requires its titanium tetrachloride facility to maintain a solid waste disposal permit, the state has focused its regulatory efforts primarily on municipal solid waste landfills. Both Ohio and Tennessee recently revised their regulations and appear to be preparing to regulate mineral processing wastes more comprehensively. If the states implement the regulations as anticipated, both titanium tetrachloride facilities could be required to upgrade their disposal management practices to include activities such as the installation of covers, liners, and ground-water monitoring, or to ship their wastes off-site to properly permitted landfills. Both Ohio and Tennessee have approved NPDES programs and require permits for all discharges to surface waters. Finally, neither Ohio nor Tennessee has applied fugitive dust emission controls to their facilities' chloride waste solids disposal activities.

Two titanium tetrachloride facilities are active in the State of Mississippi. Mississippi's solid waste regulatory program exempts mineral processing wastes that are generated, processed, and disposed of on-site. Because both of Mississippi's facilities dispose of their chloride process waste solids on-site, therefore, neither facility has been required to obtain a solid waste disposal permit. Mississippi does have an approved NPDES program, however, and requires NPDES permits of both facilities that include provisions for effluent monitoring/characterization. One of the facilities is permitted to discharge its process wastewater to surface waters while the second facility injects its process wastewater into the ground via three on-site deep wells. Mississippi has not applied fugitive dust emission control requirements to the chloride waste disposal activities of its titanium tetrachloride facilities.

A single facility is active in the State of Delaware. Of the four study states, Delaware appears to most active in regulating its single titanium tetrachloride facility under its solid waste regulations. The state has required that the facility maintain a permit and meet a variety of environmental criteria such as the collection, treatment, and disposal of leachate and the installation of liners. Delaware recently revised its solid waste regulations, though the changes appear to be more administrative than substantive. As with the other study states, Delaware has an approved NPDES program and has required that the facility maintain a discharge permit for its on-site surface impoundment. Finally, as with the other study states, Delaware has not applied fugitive dust emission controls to its facilities' chloride process solid waste disposal activities.

In summary, all of the four study states with titanium tetrachloride facilities exclude the management and disposal of chloride process waste solids from hazardous waste regulation. Of these four states, Delaware appears to be most actively regulating these wastes under its solid waste regulations. In contrast to apparently limited regulation in the past, however, both Ohio and Tennessee recently revised their solid waste regulations and appear to be preparing to regulate these wastes more stringently. All four study states have approved NPDES programs and have applied permit requirements to the titanium tetrachloride facilities within their borders that discharge to surface waters. Finally, none of the states apply fugitive dust emission controls to the disposal of chloride process waste solids.

13.5 Waste Management Alternatives and Potential Utilization

In the following paragraphs, the Agency provides a brief summary of information collected on alternative waste management practices and potential areas of utilization.

Recycling of the waste solids is the primary management alternative to the current disposal practice of neutralization and surface impoundment/landfill disposal. Laboratory tests have shown that the solid residue (approximately one-half of the sludge by weight) generated during the production of titanium tetrachloride from rutile, can be agglomerated and recycled. Recycling the solid residue would reduce the volume of waste requiring disposal, and there is reason to believe that the addition of the residue to the rutile charge could improve the chlorination characteristics of the feed materials.[18] However, while many producers of titanium tetrachloride have tried to develop methods of recycling their waste solids, as of 1987, no facilities were reported to be routinely recycling their waste solids.[19] Most facilities that have tried to recycle the waste solids have experienced operational difficulties (e.g., corrosion or reactor upsets) which caused them to abandon recycling.

Another management alternative is the recovery of columbium, tantalum, zirconium, and titanium from the waste solids. Laboratory tests have demonstrated the technical feasibility of recovering these metals (on a bench-scale) from the waste solids generated by the Timet (Henderson, Nevada), SCM (Ashtabula, Ohio), Kerr-McGee (Hamilton, Mississippi), and E.I. duPont (New Johnsonville, Tennessee) facilities. The process involves a combination of water leaching, pressure hydrolysis, and solvent extraction.[20] However, it is not known if this process is being used by any of the facilities, or if a full-scale application of the process would be technically or economically feasible at any of the titanium tetrachloride facilities.

13.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed under different regulatory scenarios by facilities producing titanium tetrachloride (dioxide). Next, the section discusses the cost implications of requiring these changes to existing waste management practices. The last part of the section discusses and predicts the ultimate impacts of the increased waste management costs faced by the facilities.

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[18] Merrill, C.C., M.M. Wong, and D.D. Blue, Beneficiation of Titanium Chlorination Residues: Preliminary Study, Report of Investigations 7221, Bureau of Mines, U.S. Department of Interior, 1969, p. 5.

[19] Krispar Technologies, Inc., Study on Titanium Chlorination Solid Wastes, Minerals & Materials Research Division, Bureau of Mines, U.S. Department of Interior, October 30, 1987, p. 145.

[20] Merrill, C.C. and D.E. Couch, Separation of Columbium, Tantalum, Titanium, and Zirconium from Titanium Chlorination Residues, Report of Investigations 7671, Bureau of Mines, U.S. Department of Interior, 1970.

13.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented above, EPA believes that waste solids generated in the production of titanium tetrachloride at some facilities exhibit the hazardous waste characteristic of EP toxicity. Accordingly, the Agency has estimated the costs associated with regulation under Subtitle C of RCRA, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus," as previously introduced in Chapter 2, and as described in specific detail below.

EPA has adopted a conservative approach in conducting its cost analysis for the wastes generated by the titanium tetrachloride production industry. The Agency has assumed that the chloride process waste solids would exhibit EP toxicity at all facilities unless actual sampling and analysis data demonstrate otherwise. EPA's waste sampling data indicate that the waste solids do not exhibit any characteristics of hazardous waste at five of the nine facilities that generate the material. The Agency's cost and impact analysis is therefore limited to four facilities.

Subtitle C

Under Subtitle C standards, generators of hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because chloride process waste solids are solid (sludge), non-combustible materials, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed of in waste piles, EPA has assumed in this analysis that the ultimate disposition of chloride process waste solids would be in Subtitle C landfills, either on-site or, if sites for land disposal are not available, off-site. Because chloride process solids are typically generated as a sludge following treatment or settling in an impoundment and because of restrictions concerning liquids in landfills, the Agency has assumed that the facilities would also construct storage surface impoundments (two per facility) to manage the sludge and prepare it for disposal. Each impoundment is assumed to have the capacity to hold one half of the waste generated annually. These impoundments would be used to settle the solids; periodically (collectively for half the year) solids are settled in one of the two impoundments. The remainder of the year the solids are routed to the second impoundment, while the sludge in the first impoundment is dried and stabilized with cement. The stabilized sludge is then dredged and landfilled. Facilities that currently ship their waste solids off-site for disposal (e.g., SCM-Ashtabula) are assumed to construct their own on-site waste management units, because this would be considerably less costly than shipment of the chloride process waste solids to a commercial hazardous waste management facility, given the volumes of waste involved.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-Minus is the facility-specific application of requirements based on risk potential at each site. Under the C-Minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating ground-water resources was used as a decision criterion in determining what level of design standards (e.g., liner and closure cap requirements) would be necessary to protect human health and the environment. All four facilities generating potentially hazardous chloride process waste solids were determined to have a high potential to contaminate ground-water resources. When risk to ground water is high, facilities are assumed to be required to manage the waste in disposal impoundments equipped with composite liners. As none of the facilities currently operate adequately lined disposal units, all four facilities would be required to build new units under the Subtitle C-Minus scenario. In addition to the composite liners, the facilities are required to install run-on/run-off controls and groundwater monitoring wells; both practices must be continued through the post-closure care period. In addition, the units must undergo formal closure, including a cap of topsoil and grass/synthetic liner/clay (three foot thickness). Post-closure care must be maintained (e.g., mowing and general cap maintenance, and groundwater monitoring) for a period of thirty years.

In addition to the cost differences between full Subtitle C and Subtitle C-Minus that are attributable to the design, construction, and operation of waste management units, a potentially significant cost difference arises from the relaxation of the sludge stabilization/solidification step that EPA has included in the full Subtitle C scenario to account for probable future Land Disposal Restrictions. Under the Subtitle C-Minus scenario, sludges are assumed to be disposed without stabilization/solidification. This implies a savings of the treatment equipment and variable costs, and the cost of disposing the greater (50 percent) quantity of stabilized material, in comparison with the full Subtitle C scenario. In addition, the treatment (i.e., settling) ponds used to separate sludge and entrained water prior to cementation are no longer required.

Subtitle D-Plus

As under both Subtitle C scenarios, facility operators under the Subtitle D-Plus scenario would be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to groundwater increases. Because the four titanium tetrachloride facilities with potentially hazardous chloride process waste solids all have high potential to contaminate groundwater resources, the facilities are assumed to require disposal in impoundments lined with composite liners, which, as pointed out above, none of the facilities currently have. Therefore, EPA has assumed that the facilities would construct new units with composite liners, and install run-on/run-off controls and groundwater monitoring wells; maintenance of these systems must be continued through the post-closure care period under this scenario, as in the others. In addition, the units must undergo formal closure, including a cap of topsoil and grass over a synthetic liner on three feet of clay. Post-closure care must be maintained (e.g., leachate/run-off collection and treatment, cap maintenance, and groundwater monitoring) for a period of thirty years. Under this scenario, EPA has assumed that the SCM-Ashtabula facility would be required to construct on-site management units that meet the Subtitle D-Plus technical standards, rather than continue to ship its chloride process waste solids off-site for disposal. In this way, adequate protection of human health and the environment would be ensured.

As in the Subtitle C-Minus scenario, EPA has not included a sludge stabilization/solidification step in the waste management sequence. This results in considerable savings over waste management under the full Subtitle C scenario.

13.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the titanium tetrachloride sector are presented by facility and regulatory scenario in Exhibit 13-6. Under the Subtitle C scenario, annualized incremental regulatory compliance costs for the sector are estimated at more than $28.0 million. The costs range from $5.4 to $9.4 million greater than baseline costs (4 to 29 times larger than baseline). Annualized capital costs range from $2.4 to $4.9 million over baseline, representing about one half of the total annual costs. Total initial compliance-related capital expenditures are $98.8 million, ranging from $16.0 million to $33.2 million.

Under the facility-specific requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about eleven percent of the full Subtitle C costs. The sector-wide annualized compliance cost is about $3.2 million greater than baseline (roughly twice the baseline costs). Total initial capital costs are estimated at about $24.8 million, ranging from $3.0 to $7.9 million. Overall, the primary differences in costs are due to decreased capital construction costs and relaxation of the sludge stabilization/solidification requirements; the difference in capital costs is primarily related to the configuration of the landfill liners, leachate collection/detection systems, and closure caps. Other waste management elements having significant cost implications (e.g., non-liner related capital construction costs, operating costs, groundwater monitoring) are identical under these two regulatory scenarios.

Exhibit 13-6
Compliance Cost Analysis Results for Management of Titanium Tetrachloride Process Waste Solids[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
duPont - New Johnsonville, TN	2,023	9,496	33,217	4,956	142	7,914	1,181	142	7,914	1,181
SCM Chemicals - Ashtabula, OH	1,934	5,986	26,569	3,965	623	7,206	1,075	623	7,206	1,075
Ker-McGee - Hamilton, MS	591	5,448	16,086	2,400	896	3,018	450	896	3,018	450
Timet - Henderson, NV	365	7,134	22,981	3,429	1,545	6,645	992	1,540	6,645	992
Total:	4,913	28,064	98,853	14,750	3,206	24,783	3,698	3,201	24,783	3,698
Average:	1,228	7,016	24,713	3,688	801	6,196	924	800	6,196	924

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Facilities modeled as generating potentially hazardous waste include those for which no sampling data exists.

Costs under the Subtitle D-plus regulatory scenario are virtually identical to those under Subtitle C-minus scenario, the only difference being slight difference in permit costs at one facility.

13.6.3 Financial and Economic Impact Assessment

To evaluate the ability of affected facilities to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of each facility and thereby generated financial impact ratios, to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the titanium tetrachloride (dioxide) industry. The methods and assumptions used to conduct this analysis are described in Chapter 2.

Financial Ratio Analysis

EPA believes that Subtitle C regulation would impose potentially significant financial impacts on all four potentially facilities in the titanium tetrachloride industry. As shown in Exhibit 13-7, the annualized capital costs associated with waste management under Subtitle C as a percentage of annual investment exceed the five percent threshold at all four facilities, ranging from 18 to 49 percent. Annualized incremental costs as a percentage of value of shipments and value added exceed the screening criteria for significant impacts in all cases; these ratios range from just under 2.0 percent to 5.3 percent.

Financial impacts under the Subtitle C-Minus scenario are significantly lower than under full Subtitle C. The annualized capital costs associated with waste management under Subtitle C-Minus as a percentage of annual investment again exceed the five percent threshold for three of the four affected firms. Annualized incremental costs as a percentage of value of shipments and value added continue to exceed the threshold for potentially significant impacts only at the Timet facility where costs ratio results are just over one percent.

Under the Subtitle D-Plus scenario, as discussed above, costs, and therefore impacts, are nearly identical to those under the Subtitle C-Minus scenario.

Market Factor Analysis

General Competitive Position

The U.S. is very competitive in titanium dioxide production on a worldwide basis. Some of the producers, such as duPont, are also partially integrated through the raw material stage. The fact that very few producers worldwide are fully integrated (with the exception of Norway and some Australian producers) puts manufacturers on a roughly equal basis in terms of raw material costs. Indeed, the fact that most producers are largely dependent on Australian rutile, ilmenite, and titaniferrous slags has led to strong price increases for these raw materials over the last ten years. The U.S. plants that previously produced titanium dioxide by the higher cost sulfate route have largely been eliminated or updated.

In terms of conversion to the chloride process, the U.S. is considerably more advanced than other countries and therefore will not undergo the capital expenditures for conversion that many other countries will likely be required to make over the next decade in order to remain cost-competitive. The fact that the U.S. is efficient (has comparatively low processing costs) and also a pioneer of chloride process technology (most notably duPont) results in the U.S. being very competitive on a worldwide basis.

Exhibit 13-7
Significance of Regulatory Compliance Costs for Management of Titanium Tetrachloride Chloride Process Waste Solids(a

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
duPont - New Johnsonville, TN	1.7%	1.9%	18.0%
SCM Chemicals - Ashtabula, OH	2.5%	3.2	33.6%
Kerr-McGee - Hamilton, MS	3.2%	4.1%	28.2%
Timet - Henderson, NV	5.1%	5.3%	49.0%
Subtitle C-Minus			
duPont - New Johnsonville, TN	0.0%	0.0%	4.3%
SCM Chemicals - Ashtabula, OH	0.3%	0.3%	9.1%
Kerr-McGee - Hamilton, MS	0.5%	0.7%	5.3%
Timet - Henderson, NV	1.1%	1.2%	14.2%
Subtitle D-Plus			
duPont - New Johnsonville, TN	0.0%	0.0%	4.3%
SCM Chemicals - Ashtabula, OH	0.3%	0.3%	9.1%
Kerr-McGee - Hamilton, MS	0.5%	0.7%	5.3%
Timet - Henderson, NV	1.1%	1.1%	14.2%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Potential for Compliance Cost Pass-Through

Labor Markets

There is a possibility for some reduction in wages, as past reductions in salary have not been comparable to that of the general mineral processing industry. The need to keep highly-skilled professionals (to maintain and expand the technological advantage of domestic producers), however, means that lower wages may cause personnel losses to competitors in other chemical industry segments.

Supply Markets

The U.S. does utilize some ilmenite, even though most plants have converted to the chloride process, which cannot use ilmenite directly as a feedstock (the sulfate process can use ilmenite directly). A large portion of the ilmenite brought to the U.S. is as a feedstock for the Kerr-McGee synthetic rutile plant in Hamilton, Mississippi, and is obtained under long-term contract.

DuPont also utilizes some ilmenite in its process, even though it uses chloride route processing, but these are largely altered ilmenites from domestic and imported (long-term contract) sources. Most U.S. plants need slag, rutile, or synthetic rutile as a feedstock. Consequently, U.S. pigment producers may be able to moderate titanium raw material price increases, but have little power to lower prices (pass compliance costs backwards).

Higher Prices

As the U.S. is a principal world producer, and foreign capacity is limited, there has been leeway to raise prices in past years. For this reason, the price of titanium dioxide pigment has already risen significantly over the last several years. There is a limit to price elasticity, however, particularly in the paper industry, where competitive materials replace (or limit) the use of titanium dioxide in some applications. The paper industry is striving to reduce consumption of titanium dioxide because of the high price levels. This has been done, particularly in plants using alkaline paper making, by increasing calcium carbonate use as a titanium dioxide extender. Although more difficult to replace in paint applications, a reduction and rationalization is a possibility if prices continue to rise.

Additional capacity worldwide will also tend to limit price increases beyond 1990. The U.S. itself produces a limited amount of raw materials to supply internal titanium dioxide requirements, and these would not be economic for export on the world market, as they simply are partial feedstocks for integrated producers.

Evaluation of Cost/Economic Impacts

EPA estimates that three and possibly a forth of the nine facilities domestically producing titanium tetrachloride would face significant impacts under full Subtitle C regulation. Costs and impacts under the nearly identical Subtitle C-Minus and D-Plus scenarios are not expected to significantly affect any facilities; only one facility, Timet/Henderson, is expected to have costs higher than one percent of value of shipments or value added.

In terms of distributing costs, it seems likely that some of the costs that would be incurred under these scenarios might be passed on in the form of higher prices. If, however, only three or four facilities are affected out of a total of nine (or a total of 11 or 12 facilities that may be operating during the next two years) increasing prices will be less likely. Also, because prices have already increased during the past few years, and because these higher prices are reducing demand for titanium dioxide (the primary product from processing the titanium tetrachloride), the industry may not be able to raise prices enough to fully recover compliance costs. In addition, within several years, additional domestic capacity is expected to become operational making increases in prices in order to pass on compliance costs very difficult.

Given the moderate nature of the prospective cost impacts of modified Subtitle C and Subtitle D regulation, and the healthy and globally competitive position of domestic titanium tetrachloride producers, EPA does not believe that potential regulatory compliance costs under the RCRA Subtitle C-Minus scenario would impose significant economic impacts upon affected facilities. Although these costs would not be shared among all domestic producers (affected facilities account for approximately 26 percent of domestic capacity), and therefore, affected facilities might be put at a competitive disadvantage with respect to other domestic producers, the Agency does not believe that the long-term profitability and continued operation of these plants would be threatened by a decision to regulate chloride process waste solids under modified Subtitle C standards. In addition, adequately protective standards and their costs under a modified Subtitle C program are in many ways identical to the probable standards and costs that would result from Subtitle D regulation, suggesting that generators of this waste may face costs from modifying their existing waste management practices regardless of whether this waste remains within the Mining Waste Exclusion.

13.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For the special waste generated by facilities in this commodity sector (chloride process waste solids), these categories address the following three major topics: (1) the potential and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of the chloride process waste solids is relatively high (at some facilities) compared to the other mineral processing wastes studied in this report. Based on EP leach test results, 3 out of 16 samples (from 3 of 7 facilities tested) contain chromium concentrations in excess of the EP toxicity regulatory levels; lead was also measured in EP leachate in concentrations that exceed the regulatory level in 1 out of 16 samples (from 1 of 6 facilities tested). Chromium and lead concentrations measured in SPLP (EPA Method 1312) leachate also exceed the EP toxicity regulatory levels at one facility for which comparable SPLP test data are available. Moreover, the waste solids contain 12 constituents in concentrations that exceed the risk screening criteria used in this by more than a factor of 10. Nine of these constituents are metals that are expected to be relatively mobile if released to ground water, considering the acidic nature of the leachate. The waste solids may also contain uranium-238, thorium-232, and their decay products in concentrations that could pose an unacceptably high radiation risk if the solids were allowed to be used in an unrestricted manner. All of these factors lead EPA to conclude that the waste solids could present a significant hazard if mismanaged.

Based on an examination of existing release/exposure conditions at the nine active titanium tetrachloride facilities, EPA further concludes that management of the waste solids could allow contaminants to migrate into the environment, but that the potential for significant exposures to this contamination is currently low. For example, half of the facilities have a moderate to high potential for contaminants to migrate into ground water because they have large unlined surface impoundments and/or are underlain by shallow ground water, most facilities are adjacent to creeks or rivers into which contaminants might migrate, and the solids are susceptible to wind erosion when managed in uncovered piles or landfills. Based on predictive modeling for the "most sensitive" sites, EPA estimates that the concentrations of arsenic in ground water at the property boundary could pose a lifetime cancer risk as high as 3×10^{-4}. In terms of current exposures, however, nobody presently drinks the ground water at this location, and the predicted arsenic concentration at the nearest existing residence that could have a drinking water well would pose a cancer risk of less than 10^{-10}. The Agency's predicted concentrations of contaminants in surface waters near the sites are well below human health and environmental protection benchmarks. Similarly, EPA's predicted concentrations of windblown contaminants at locations of existing residences would pose a cancer risk of no more than 2×10^{-7}.

Based on the lack of documented cases of damage caused by the waste solids, it appears that the solids, as currently managed, have not caused significant human health or environmental impacts. State and EPA Regional files were reviewed and regulatory staff were interviewed in an effort to document the performance of waste management practices for chloride process waste solids at the nine active titanium facilities as well as two inactive facilities. Through these case studies, EPA found no documented environmental damages attributable to management of chloride process waste solids from titanium tetrachloride production at any of these facilities. Some cases of documented damage attributable to other wastes were identified at some titanium facilities, however, and it is possible, though not demonstrated, that waste solids have contributed to these observed damages.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

At several of the active facilities, the current waste management practices and environmental conditions may allow contaminant releases and risks in the future in the absence of more stringent regulation. For example, only 2 of the 15 impoundments and none of the landfills or waste piles used to manage the solids are equipped with either a synthetic liner or leachate collection system, even though usable ground water at many sites is relatively shallow (6 meters deep or less) and separated from the base of the units by relatively permeable earth materials. Many of the facilities are also located in humid areas with moderate to high rainfall and ground-water recharge rates, which can lead to contaminant migration. Similarly, none of the four facilities that manage the solids in waste piles or landfills practice any dust suppression, even though the waste solids are susceptible to wind erosion when managed in a dry form. Therefore, contaminant migration during the operating life of most units appears possible, and these releases could persist after closure if the units are not closed properly. Considering the intrinsic hazard of the waste, significant exposures to these releases could occur if nearby ground water is used.

The titanium tetrachloride production industry is also expected to expand in the future. The Bureau of Mines has reported that it expects an increase in titanium tetrachloride production capacity of approximately 600,000 metric tons by 1992 (current national production capacity is estimated to be 1.8 million metric tons per year). This increased production capacity likely will be made up by the addition of new facilities, for which management practices (in the absence of regulation) and environmental settings cannot be predicted at this time. Depending on the environmental characteristics of these sites, releases and risks could result if the waste solids are not properly managed.

The existing state regulatory programs appear to provide only limited control over the management of the waste solids, though they are growing more stringent in some states. With the possible exception of California, the eight states where titanium tetrachloride facilities are currently located exclude the waste solids from hazardous waste regulations. Based on a review of the regulatory programs in four states (Delaware, Mississippi, Ohio, and Tennessee), only Delaware appears to be regulating the waste solids extensively. The waste solids in Ohio and Mississippi are not subject to solid waste permit requirements, and Tennessee has focused its regulatory efforts on municipal solid waste problems rather than mining and mineral processing wastes. Delaware, Ohio, and Tennessee, however, have all recently adopted new regulations that could be used to address titanium waste solids and other mineral processing wastes more directly and comprehensively.

Costs and Impacts of Subtitle C Regulation

EPA has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. EPA's waste characterization data indicate that chloride process waste solids may exhibit the hazardous waste characteristic of EP toxicity at as many as four of the nine active facilities. Therefore, the Agency's cost and impact analysis is limited in scope to these four facilities, because the remaining five plants would not be affected by a decision to remove this waste from the Mining Waste Exclusion. These four plants in combination account for approximately 26 percent of domestic titanium tetrachloride production.

Costs of regulatory compliance exceed $3 million annually, even under the least stringent (Subtitle D-Plus) scenario. Full Subtitle C regulation implies potentially significant economic impact at all four facilities, while application of the more flexible Subtitle C-Minus regulatory scenario would result in compliance costs that are approximately 75 percent lower. Costs under the Subtitle C-Minus and Subtitle D-Plus scenarios are almost identical, because adequately protective waste management unit design and operating standards are essentially the same under both scenarios, given the nature of the waste and the environmental settings in which it is currently managed. EPA's economic impact analysis suggests that the operators of potentially affected titanium tetrachloride plants could pass through a portion of any regulatory compliance costs that they might incur to product consumers. Demand for and prices of titanium dioxide, the principal end-product of titanium tetrachloride manufacturing, have been strong in recent years, as evidenced by the fact that four new domestic plants are projected to be on-line by 1992. Consequently, EPA believes that regulation of chloride process waste solids from titanium tetrachloride production under Subtitle C of RCRA would not threaten the long-term profitability or economic viability of any of the facilities that generate this waste.

Finally, EPA is not aware of any significant recycling or utilization initiatives that would be hampered by a change in the regulatory status of this waste. Recycling has been attempted in the past, but has not been operationally successful. There have also been attempts to recover tantalum, columbium, and other rare earth metals from the chloride process waste solids, but the techniques employed are at an early (bench-scale) stage of development.

Chapter 14
Primary Zinc Processing

For purposes of this report, the primary zinc processing sector consists of one facility that, as of September 1989, was the only active zinc facility using pyrometallurgical (smelting) techniques and reported generating a special waste from mineral processing: slag from primary zinc processing. Three additional facilities are also primary producers of zinc. These facilities, however, use electrolytic production techniques that do not generate any special wastes, that is, the wastes from electrolytic productions are no longer Bevill excluded wastes.[1] Therefore, the primary electrolytic processors' operations are not discussed in this report. The information included in this section is discussed in additional detail in a technical background document in the supporting public docket for this report.

14.1 Industry Overview

Zinc metal is used in many applications, primarily in the construction, transportation, machinery, electrical, and chemical industries. The predominant use is for galvanizing and electrogalvanizing; other applications include manufacture of brass, bronze, zinc-based alloys, and rolled zinc. Zinc oxide is the most widely used compound of zinc, and is used both for its light-sensitive characteristics and as a starting material in the production of other zinc chemicals.[2]

The sole pyrometallurgical zinc production facility in the U.S. is located in Monaca, Pennsylvania. The facility is operated by Zinc Corporation of America (ZCA); that company is in turn owned by Horsehead Industries, headquartered in New York City. The facility initiated operations in 1936 and was modernized in 1980, at which time four electrothermic furnaces began operation. The facility's 1988 annual capacity, based on a 366 day year, was 101,300 metric tons of zinc. In 1988, the annual capacity utilization rate was 98.5 percent, based on total 1988 reported production of 99,800 metric tons of zinc.[3]

In 1989, zinc consumption increased in the Western World (i.e., the world market not including Eastern European countries) for the seventh consecutive year. A major force in zinc's performance has been the strong demand from the automobile industry for galvanized sheet metal. Galvanizing accounted for 45 percent of zinc consumption in 1989, followed by brass manufacturing at 20 percent and die casting at 15 percent. While zinc demand is likely to stabilize in 1990, due to a slowdown in North America, it is expected to rise again in 1991.[4]

Because of the steadily increasing demand for galvanized sheet metal - the healthy growth trend for zinc witnessed in the 1980's is likely to continue into the 1990's. In 1989, U.S. production of mined zinc rose by 17 percent, to 300,000 metric tons; this marked the third straight year that production rose, owing to the startup of six new and reopened mines.[5] By 1991, U.S. mine production of zinc could double that of 1989 due, primarily, to the huge Red Dog, Alaska mine, which opened in November 1989.[6] However, increased domestic zinc mining is not expected to raise U.S. metal production, because most new mine output is scheduled for export because of a lack of zinc smelting capacity in the United States.[7]

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[1] In addition to the primary facilities, as many as ten secondary facilities may be operating; the operations conducted at these facilities, however, fall outside the definition of primary mineral processing and, accordingly, do not generate special mineral processing wastes.

[2] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 929.

[3] Zinc Corporation of America, 1989(a). Response to "National Survey of Solid Wastes from Mineral Processing Facilities", 1989.

[4] Edward M. Yates, "Zinc: Prices Top Out in 1989," E&MJ, March 1990, p. 20-22.

[5] Ibid.

[6] James H. Jolly, U.S. Bureau of Mines, Mineral Commodity Summaries, 1990 Ed., p. 191.

While primary zinc slab production has remained relatively flat in the late 1980's (up only 1.5 percent since 1985, from 261,000 metric tons to 265,000 metric tons), secondary zinc slab production has shown a strong increase, up 51 percent since 1985 from 73,000 metric tons to 110,000 metric tons. Another trend evident in the late 1980's and likely to continue in the near future is the use of electrolytic zinc smelting techniques. During the 1980's the zinc industry has moved steadily away from pyrometallurgical smelting operations to the more energy efficient, cost effective electrolytic smelting operations. Only one primary pyrometallurgical zinc smelting facility -- the Monaca, Pennsylvania that is described in this chapter -- is currently operating in the United States. Any new zinc slab primary processing capacity, developed to meet increased demand for zinc, will likely come from electrolytic facilities rather than pyrometallurgical facilities. However, because of its ability to process secondary materials, the Monaca facility is likely to be able to maintain its market position for the forseeable future.

In the smelting process, zinc is vaporized from sintered calcine in retort furnaces and then condensed and recovered (see Exhibit 14-1).[8] At the Monaca facility, medium to high grade sulfide concentrates are roasted and sintered in preparation for retorting. Significant quantities of high-grade calcine extracted from electric air furnace (EAF) dust and other secondary materials (e.g., skimmings and drosses) that are not as readily recoverable in electrolytic zinc plants are used to supplement the ore concentrate feed.[9,10] The ore concentrate and secondary feed values are charged along with an equal volume of coke into the top of one of four vertical shaft electrothermic furnaces.[11] Electric current, supplied from a company owned coal-fired power plant, flows through the charge, supplying the energy required for the reduction reaction through resistance heating. Zinc vapor from the retorts passes into distillation columns in the refinery where the purified zinc vapor is collected as a liquid metal and cast into metal or processed into various products. A solid residue remains behind in the retort furnace; this is the zinc slag that is the special waste.

14.2 Waste Characteristics, Generation, and Current Management Practices[12]

The zinc slag that is removed from the furnaces is a rock-like solid material (pieces range in size from three inches to a foot in diameter) composed primarily of iron, silicon, and unreacted coke. Non-confidential waste generation rate data were reported for this material by the ZCA. The generation of furnace slag was approximately 157,000 metric tons in 1988, thus, the 1988 waste-to-product ratio was 1.6 metric tons of slag to each metric ton of zinc product.

At the Monaca facility, the slag from the furnace goes directly to one of two crushers while it is still red hot. A series of crushing/separation operations are employed to separate the slag into the four material streams shown in Exhibit 14-2.

The fines and coke are recycled to beneficiation and processing operations at the facility. On the other hand, the processed slag is stored in slag waste piles, disposed in a flyash landfill, or sold for such uses as road gravel or construction aggregate, while the ferrosilicon is accumulated in a stockpile until it can be sold. The processed slag is (ranging in size from approximately 1.3 cm to 6.4 cm (0.5 to 2.5 inches) accumulated in the storage piles (some of which is subsequently used as road gravel or in the flyash landfill),

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[7] Ibid.

[8] Marks, 1978. Encyclopedia of Chemical Technology, Marks, et al., editors; Wiley Interscience, New York, NY, 1978; p. 827.

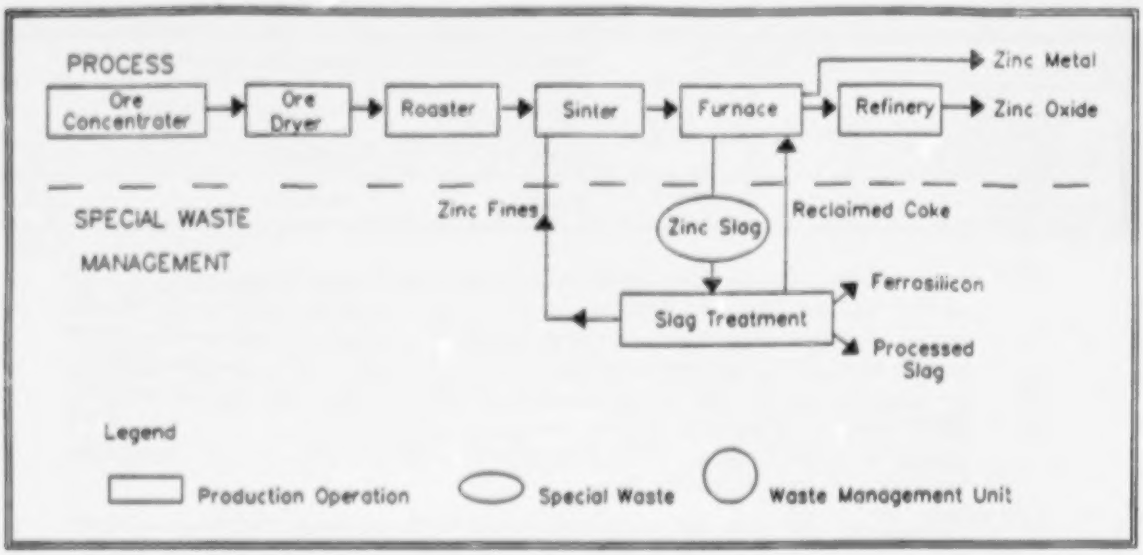
[9] James H. Jolly, 1990. Personal communication, June 27, 1990.

[10] Weiss, 1985. SME Mineral Processing Handbook, Weiss, N.L., editor; Society of Mining Engineers, NY, NY, 1985; pp. 15:11-12.

[11] Zinc Corporation of America, 1989(b). Public comments from Zinc Corporation of America addressing the 1989 proposed Reinterpretation of the Mining Waste Exclusion (Docket No. -- MWRP00073); May 30, 1989; Appendix A.

[12] All responses, unless noted are from the response of Zinc Corporation of America to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities", conducted in 1989.

Exhibit 14-1
Pyrometallurgical Primary Zinc Processing


PROCESS
Ore Concentrator
Ore Dryer
Roaster
Sinter
Furnace
Refinery
Zinc Metal
Zinc Oxide
SPECIAL WASTE MANAGEMENT
Zinc Fines
Zinc Slag
Reclaimed Coke
Ferrosilicon
Slag Treatment
Processed Slag
Legend
Production Operation
Special Waste
Waste Management Unit

while the ferrosilicon pile contains particles that are typically about 0.64 cm in size.

Of the 157,000 metric tons of total raw zinc slag generated at the zinc processing facility in 1988, 28,000 metric tons and 17,000 metric tons were separated out as processed slag and ferrosilicon, respectively. The ferrosilicon is accumulated in a pile that is approximately 7 meters high and has a basal area of 8,000 square meters (2 acres). The processed slag pile (in several adjacent piles) covers an area of about 1.2 hectares and is roughly 7 meters in height. In addition, slag has been placed in a layer at the bottom of the facility's flyash landfill that is approximately 0.3 meters (1 foot) deep and covers an area of about 8 hectares. Slag has also been used as gravel on parking lots and other areas of the plant site. As of 1988, the quantities of waste accumulated in the ferrosilicon pile, processed slag pile, and the landfill were roughly 48,000, 63,500, and 45,400 metric tons, respectively.

Using available data on the composition of zinc slag, processed slag, and ferrosilicon, EPA evaluated whether any of these materials exhibit any of the four hazardous waste characteristics: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, EPA does not believe that any of the three materials are corrosive, reactive, or ignitable; however, samples of all three frequently exhibit the characteristic of EP toxicity based on the lead content, as shown below.

- Generated Slag. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for one sample of zinc slag from the Monaca facility. Of these constituents, only lead was found to exceed the EP toxicity regulatory level, by a factor of 12. The zinc slag sample that failed the EP toxic level was also analyzed using the SPLP leach test; this test indicates that the lead concentration was three orders of magnitude below the EP toxic level.

Exhibit 14-2

Primary Management of Zinc Slag

Residual Stream	Quantity (mt/yr)	Residual Management
Zinc fines	79,000	Returned to Sinter Plant
Reclaimed Coke	33,000	Recycled to Retort Furnace
Processed Slag	28,000	Disposed
Ferrosilicon	17,000	Stockpiled

- Processed Slag. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for 36 samples of processed slag from the Monaca facility. Of these constituents, only lead was found to exhibit the characteristic of EP toxicity for lead in 25 samples by as much as a factor of 12.8. One of the processed zinc slag samples that exhibited the characteristic of EP toxicity was also analyzed using the SPLP leach test; these data indicate that the concentration of lead measure exhibited the characteristic of using the SPLP leach test was roughly three orders of magnitude below the EP toxic regulatory level.
- Ferrosilicon. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for one sample of ferrosilicon from the Monaca facility. The only constituent detected in the ferrosilicon in a concentration that exceeds the EP level was lead (it exceeded the EP level by a factor of almost 10). The ferrosilicon sample that failed the EP toxic level was also analyzed using the SPLP leach test; the resulting concentration of lead was three orders of magnitude below the EP toxic levels.

14.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proven. Overall conclusions about the hazards associated with zinc slag are provided after these two study factors are discussed.

14.3.1 Risks Associated With Processed Zinc Slag and Ferrosilicon

Because two of the four material streams arising from zinc slag processing are recycled directly to the production process without any potential contact with the environment, EPA's risk analysis of primary zinc slag is limited to an examination of the processed slag and the ferrosilicon. Any potential danger to human health and the environment from these two wastes is a function primarily of the composition of these materials, the management practices that are applied to them, and the environmental setting of the facility where the processed zinc slag and ferrosilicon are generated and managed. These factors are discussed separately below for each material, followed by EPA's risk modeling results.

Constituents of Potential Concern in Processed Zinc Slag

EPA identified chemical constituents in the processed zinc slag (as managed) that may pose a risk by collecting data on the composition of slag from the Zinc Corporation of America facility in Monaca, and evaluating the intrinsic hazard of the chemical constituents present in the slag.

Data on Processed Zinc Slag Composition

EPA's characterization of processed zinc slag and its leachate is based on data from two sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); and (2) industry responses to a RCRA §3007 request in 1989. (The §3007 data provided only results of EP leach test analyses.) These data provide information on the concentrations of 19 metals and chloride in total solids and leach test analyses. Concentrations of most constituents from leach test analyses of the processed zinc slag generally are consistent across the data sources and types of leach tests (i.e., EP and SPLP). EP leach test concentrations of zinc, however, were approximately four orders of magnitude higher than zinc concentrations in SPLP leach test analyses.

Process for Identifying Constituents of Potential Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the zinc slag data to determine if the slag or slag leachate contain any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to conservative screening criteria and then by evaluating the environmental persistence and mobility of any constituents present in concentrations above the criteria. These screening criteria are conservative because they were developed using assumed scenarios that are likely to overestimate the extent to which the zinc slag constituents are released to the environment and migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and water resources (see Exhibit 2-3). Given the conservative nature (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the slag in greater detail.

Identified Constituents of Potential Concern

Exhibits 14-3 and 14-4 present the results of the comparisons for zinc slag solid and leach test analyses, respectively, to the screening criteria described above. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Of the 20 constituents analyzed in the zinc slag solids, only chromium, lead, nickel, and selenium are present at concentrations exceeding the screening criteria (see Exhibit 14-3). These four metals were detected in all samples analyzed, but based on the frequency and magnitude of their concentrations exceeding the screening criteria, chromium and lead are of greater potential concern. Chromium exceeded the inhalation criterion by as much as a factor of 13 and lead exceeded the ingestion criterion by a factor of 6; nickel and selenium exceeded the criteria by a factor of roughly 1.2. All of these constituents are persistent in the environment (i.e., they do not degrade).

Exhibit 14-3
Potential Constituents of Concern in Zinc Slag Solids[a]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Human Health Screening Criteria[b]	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Chromium	2 / 2	Inhalation*	2 / 2
Lead	2 / 2	Ingestion	1 / 2
Nickel	2 / 2	Inhalation*	1 / 2
Selenium	2 / 2	Inhalation	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

These exceedances of the screening criteria indicate the potential for two types of adverse effects, as follows:

- Lead concentrations in processed zinc slag may cause adverse health effects if a small quantity of zinc slag or soil contaminated with the slag is inadvertently ingested on a routine basis (e.g., if children playing on abandoned waste piles or driveways made from slag were to inadvertently ingest the slag).
- Chromium, and to a lesser extent, nickel and selenium concentrations exceed the health-based screening criteria for inhalation. Thus, chromium and nickel could pose a cancer risk (i.e., greater than $1x10^{-5}$) while selenium could cause adverse noncancer effects if slag dust is blown into the air and is inhaled in a concentration that equals or exceeds the National Ambient Air Quality Standard for particulate matter. However, as discussed in a following section, the Agency does not expect such large releases and exposures because the vast majority of the waste slag exists as particles too large to be suspended, transported, or respired. It is likely that only a very small fraction of the slag will be weathered and aged (or crushed) into smaller particles that can be suspended in air and cause airborne releases and related impacts.

Based on a comparison of leach test concentrations of 20 constituents to surface and ground-water pathway screening criteria (see Exhibit 14-4), nine constituents (lead, manganese, zinc, copper, cadmium, nickel, arsenic, selenium, and iron) are present in concentrations that occasionally exceed the criteria. Of these constituents, lead, manganese, zinc, and copper appear to present the greater potential hazard because their concentrations in all samples analyzed exceed at least one screening criterion. Only lead, manganese, zinc, and arsenic exceeded the screening criteria by a factor of 10 or more, and only lead was detected in concentrations above the EP toxicity regulatory level. All of these constituents are inorganics that do not degrade in the environment.

Exhibit 14-4

Potential Constituents of Concern in Zinc Slag Leachate[(a)]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Screening Criteria[(b)]	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Lead	35 / 35	Human Health Resource Damage Aquatic Ecological	34 / 35 35 / 35 34 / 35
Manganese	2 / 2	Resource Damage	2 / 2
Zinc	2 / 2	Human Health Resource Damage Aquatic Ecological	2 / 2 2 / 2 2 / 2
Copper	2 / 2	Aquatic Ecological	2 / 2
Cadmium	29 / 34	Human Health Resource Damage Aquatic Ecological	1 / 34 4 / 34 4 / 34
Nickel	2 / 2	Resource Damage Aquatic Ecological	1 / 2 2 / 2
Arsenic	2 / 26	Human Health*	2 / 26
Selenium	1 / 24	Resource Damage	1 / 24
Iron	2 / 2	Resource Damage	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- If the slag leachate is released and diluted by only a factor of 10 during migration to a drinking water supply, concentrations of lead, zinc, cadmium, and arsenic in zinc could cause adverse health effects from the long-term chronic ingestion of untreated drinking water. The diluted concentration of arsenic could pose a cancer risk of greater than $1x10^{-5}$ from drinking water exposures.
- Concentrations of lead, zinc, copper, cadmium, and nickel in zinc slag leachate could threaten aquatic organisms if the leachate enters surface water and is diluted by a factor of 100.
- If released to ground water or surface water and diluted by a factor of 10 or less during migration, lead, manganese, zinc, cadmium, nickel, selenium, and iron concentrations in zinc slag leachate potentially could exceed drinking water maximum contaminant levels or irrigation guidelines.

These exceedances of the screening criteria, by themselves, do not demonstrate that zinc slag poses a significant risk, but rather indicate that the slag could pose a risk under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the slag to cause significant impacts, EPA analyzed the actual conditions that exist at the facility that generates and manages the waste (see the following section on release, transport, and exposure potential).

Constituents of Potential Concern in Ferrosilicon

Using the same process summarized for processed slag, EPA identified chemical constituents in the ferrosilicon that may pose a risk by collecting data on the composition of this material from the Monaca facility, and evaluating the intrinsic hazard of the chemical constituents present in the ferrosilicon.

Data on Ferrosilicon Composition

EPA's characterization of ferrosilicon and its leachate is based on data from OSW's 1989 sampling and analysis effort. These data provide the concentrations of 18 metals in total solids and leach test (both EP and SPLP) analyses, and represent samples of the ferrosilicon as it is managed at the Monaca plant.

Concentrations of most constituents from leach test analyses of the ferrosilicon generally are consistent across the two types of leach tests. EP leach test concentrations of zinc and lead, however, were almost three orders of magnitude higher than the concentrations of these metals in SPLP leach test analyses.

Identified Constituents of Potential Concern

As in the zinc slag, only chromium, lead, nickel, and selenium are present in the ferrosilicon at concentrations exceeding the screening criteria. Although the concentrations of all four of these constituents exceed screening criteria in all samples analyzed, lead and chromium exceed the criteria by the widest margin (lead exceeds by a factor of 20 and chromium exceeds by a factor of 9; nickel and selenium exceed by a factor of 4 or less). Just like the slag, lead concentrations in ferrosilicon exceed the screening criterion for ingestion, while chromium, and to a lesser extent, nickel and selenium concentrations exceed the health-based screening criteria for inhalation.

Based on a comparison of leach test concentrations for the 18 constituents to the surface and ground-water pathways screening criteria (see Exhibit 14-5), seven metals (lead, manganese, copper, nickel, zinc, selenium, and iron) were detected at levels above the screening criteria. Concentrations of these metals in all samples analyzed exceed at least one screening criterion. However, lead, manganese, and copper exceed the screening criteria by the widest margins. Lead exceeds by as much as a factor of 970, and copper and manganese exceed by factors of 24 and 30, respectively. The concentrations of the other constituents exceed the screening criteria by less than a factor of 10. Only lead was detected in a concentration that exceeds the EP toxicity regulatory level.

These exceedances indicate the potential for three types of impacts, as follows:

- Concentrations of lead and nickel in ferrosilicon leachate could cause adverse health effects from the long-term chronic ingestion of untreated drinking water if the leachate migrates to drinking water supplies with only a tenfold dilution. The diluted concentration of arsenic in slag leachate could pose a cancer risk of greater than $1x10^{-5}$ from drinking water exposures.
- Concentrations of lead, copper, nickel, and zinc in leachate from the ferrosilicon could present a threat to aquatic organisms if the leachate enters a surface water and is diluted by a factor of 100.

Exhibit 14-5
Potential Constituents of Concern in Ferrosilicon Leachate[(a)]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Screening Criteria	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Lead	1 / 1	Human Health Resource Damage Aquatic Ecological	1 / 1 1 / 1 1 / 1
Manganese	1 / 1	Resource Damage	1 / 1
Copper	1 / 1	Aquatic Ecological	1 / 1
Nickel	1 / 1	Human Health Resource Damage Aquatic Ecological	1 / 1 1 / 1 1 / 1
Zinc	1 / 1	Resource Damage Aquatic Ecological	1 / 1 1 / 1
Selenium	1 / 1	Resource Damage	1 / 1
Iron	1 / 1	Resource Damage	1 / 1

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

- Lead, manganese, nickel, zinc, selenium, and iron may be present in ferrosilicon leachate at concentrations that, if released to ground or surface water and diluted by a factor of 10 or less, potentially could exceed drinking water maximum contaminant levels and irrigation guidelines.

As explained for zinc slag, these exceedances do not demonstrate that ferrosilicon poses human health or environmental risks, but rather indicate that the waste could pose risks under a very conservative, hypothetical set of exposure conditions. To examine the potential hazards of ferrosilicon in greater detail, EPA proceeded to the next step of the risk assessment to evaluate the actual release, transport, and exposure conditions at the Monaca facility.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of processed slag and ferrosilicon as they were managed at the Monaca plant in 1988:

- Processed zinc slag is stored in a waste pile and is used as drainage material in a flyash landfill. The slag pile covers an area of 1.2 hectares (3 acres) and is roughly 7 meters (23 feet) in height. The processed slag in the flyash landfill is approximately 0.3 meters deep and covers an area of 8 hectares.
- Ferrosilicon is accumulated in a pile that is approximately 7 meters (23 feet) high and has a basal area of 0.8 hectares (2 acres).

For this analysis, the Agency did not assess the hazards of off-site disposal or use of the wastes because neither waste is disposed off-site. Although a portion of the slag is sold for off-site use as road gravel or construction aggregate and there are plans to sell the ferrosilicon for use off-site as a source of iron, insufficient information is available to support a detailed analysis of the risks posed by these off-site operations. Existing and potential off-site management practices of these wastes, however, are discussed generally in Section 14.5. In addition, the following analysis does not consider the hazards associated with variations in waste management practices or potentially exposed populations in the future because of a lack of adequate information on which to base projections of future conditions.

Ground-Water Release, Transport, and Exposure Potential

The EPA and industry test data discussed above show that several constituents are capable of leaching from the processed zinc slag and ferrosilicon in concentrations that exceed the screening criteria. However, considering the existing waste management practices and neutral pH of the leachate, the only slag contaminants that are expected to be mobile in ground water if released are cadmium, arsenic, and selenium. The single ferrosilicon contaminant that is expected to be mobile in ground water is selenium.

The potential for these contaminants to be released to a useable aquifer and transported to exposure points is determined by a number of site-specific factors, such as the presence of engineered ground-water protection controls, depth to ground water, precipitation and net recharge, presence of intervening confining layers/aquifers, and the distance to down-gradient drinking water wells.

Because there are no liquids associated with the processed zinc slag as it exists in the waste pile or the landfill, there is no hydraulic head to drive the flow of contaminants from these management units. Similarly, no liquids are associated with ferrosilicon in its waste pile. Therefore, the potential for contaminants from these two wastes to leach into ground water is entirely dependent on the extent to which precipitation can infiltrate through the slag and into the ground. The annual precipitation at the location of this facility is relatively high (91 cm/year). Much of this precipitation is expected to infiltrate into ground water because the subsurface is generally quite permeable (i.e., net recharge at this location is a relatively high 25 cm/year). Thus, in the absence of engineered ground-water protection controls, leachate originating from the waste management units could seep into the ground. Useable ground water at the site, however, is relatively deep, approximately 24 meters beneath the units, and therefore somewhat protected from contamination.

The processed zinc slag pile and the ferrosilicon pile are not equipped with any engineered controls such as liners or leachate-collection systems to limit releases to ground water. However, the landfill in which zinc slag is used as a drainage material is underlain by in-situ clay and is equipped with a leachate collection system. Given these management controls and the hydrogeological characteristics of the area, the potential for processed zinc slag and ferrosilicon leachate to migrate from the waste piles to ground water is moderate to high. Slag leachate could also migrate from the landfill to ground water if the in-situ clay layer beneath the unit is discontinuous or the leachate collection system were to fail. However, monitoring at the facility indicates that drinking water standards have not been exceeded in the ground water. In addition, the concentration of some contaminants, most notably lead and zinc, in actual leachate is likely to be less than in the EP leachate because current disposal practices do not expose the wastes to sources of organic acids.

The aquifer beneath the facility currently supplies both drinking and commercial/industrial water. A drinking water well serving the Beaver County Home and Hospital is located very close to the facility (approximately 120 meters); however, this well appears to withdraw water from the deep useable aquifer and is unlikely to be significantly affected by the waste leachate. Thus, the potential for exposure is likely to be minimal. The Agency has no data on the presence of shallower ground water at this site, but considering the close proximity of the facility to the Ohio River, shallow ground water probably does exist. Any shallow ground water, however, is likely to discharge directly into the river and does not appear "useable."

Surface Water Release, Transport, and Exposure Potential

In theory, constituents of potential concern from processed zinc slag in the landfill and waste pile, as well as from the ferrosilicon in the waste pile, could enter surface waters by migration of leachate from the waste management units through ground water that discharges to surface water, or direct overland (stormwater) run-off of dissolved or suspended materials. As discussed above, the following constituents leach from the processed zinc slag and ferrosilicon under the conditions of the EP-toxicity test at levels above the screening criteria and are mobile in ground water: cadmium, arsenic, and selenium. Other constituents in the processed zinc slag and the ferrosilicon theoretically could pose a threat if they migrated into surface waters in the form of suspended particles.

The physical form of the processed zinc slag and the ferrosilicon should help limit the overland erosion of solids from the waste piles. The slag accumulated in the pile consists of particles of four sizes, typically ranging in size from approximately 0.2 to 7.5 cm while ferrosilicon accumulated in the waste pile consists of particles that are approximately 0.64 cm in size. Because only particles that are 0.1 mm or less in size tend to be appreciably erodible,[13] only a very small fraction of the zinc slag or ferrosilicon solids are likely to erode to any significant extent. The potential for stormwater run-off to carry both the erodible fraction of zinc slag and ferrosilicon and dissolved constituents from these wastes is high because the precipitation in this area is high (91 cm/year), the slope of the land is relatively steep (6 to 12 percent), and the waste pile lacks stormwater run-on/run-off controls to prevent surface erosion. Such routine releases are of less concern at the landfill because it is equipped with stormwater run-on/run-off controls (and because the slag is located in the subsurface drainage layer of this unit). Overland run-off could migrate to the Ohio River located a short distance away (60 meters) from the facility. Episodic overland releases to the river could also occur in a flood event because the facility is located in the 100-year floodplain. The moderate to high potential for release to ground water (as discussed above) could also release constituents of the two wastes to the river via discharge of contaminated ground water.

Although migration from the two waste piles and the landfill to the Ohio River are likely, any contaminants reaching the river would be diluted rapidly due to its very large flow (approximately 23,000 mgd). Therefore, migration of contaminants to the river could pose a moderate, but not high, risk to aquatic organisms and could moderately restrict possible future uses of the river (e.g., for drinking water supply). It should be noted that as far as the Agency knows, there are currently no intakes for drinking water or other consumptive uses of this river for at least 24 km (15 miles) downstream of the facility.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern are nonvolatile, zinc slag and ferrosilicon contaminants can only be released to air in the form of dust particles. The particles can be either blown into the air by wind or suspended in air by waste dumping and crushing operations. Factors that affect the potential for such airborne releases include the particle size of the slag and ferrosilicon, the height and exposed surface area of the waste piles, the number of days with precipitation that can suppress dust, the use of dust suppression controls, wind speeds, and the proximity of receptors to the Monaca facility. If airborne releases were to occur, chromium, nickel, and selenium in the zinc slag and ferrosilicon dust could pose a risk through the inhalation pathway.

In general, particles that are $\leq$ 100 micrometers (μm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 μm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 μm in diameter are respirable. As mentioned previously, the smallest zinc slag particles are approximately 2 mm in diameter. The ferrosilicon particles are mostly approximately 6.4 cm in size, and furthermore, they are relatively heavy due to their high iron content. Therefore, the vast majority of the processed slag and ferrosilicon should not be suspendable, transportable, or respirable. It is likely that only a very small fraction of the slag and the ferrosilicon will be weathered and aged (or crushed) into smaller particles that can be suspended in air and cause airborne exposure and related impacts.

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[13] As indicated by the soil erodibility factor of the USDA's universal soil loss equation.

At Monaca, airborne releases from processed zinc slag in the landfill are not of concern because it is used as drainage material at the bottom of the unit. The processed zinc slag pile at this facility is relatively small (7 meters high and covers 1.2 hectares), as is the ferrosilicon pile (7 meters high and covers 0.3 hectares). Neither pile is covered with either vegetation or a synthetic material. Although the facility does not use any dust suppression controls, such as sprinkling water on the piles, the number of days with rain that may suppress dust is relatively large (119 days/yr). As a result, the surface of the two waste piles may be moist for almost a third of the time. While the Agency assumes that there are short term gusts of stronger winds, average wind speeds at Monaca range from 2.7 to 4.6 m/s, which are strong enough to produce wind erosion of any fine particles that may exist on the surface of the waste piles. Based on these factors, the potential for dusting is low at both waste piles. However, if particles are released from these waste management units, the potential for exposure is high because of the short distance to the nearest residence (90 meters), the relatively short distances to residences (180 meters to 670 meters) in directions with maximum wind frequency and wind speed, and the relatively large population within 1.6 km (958 people) and 8 km (approximately 52,000 people).

Proximity to Sensitive Environments

The Zinc Corporation of America facility is located in a 100-year floodplain, which indicates that large, episodic releases of contaminants in zinc slag and/or ferrosilicon could occur during large flood events. The dilution capacity of the Ohio River would be very high during these events, but a large washout could introduce a heavy load of zinc slag and ferrosilicon which could act as a source of contaminants for years to come.

Risk Modeling

Based on the preceding analysis of the intrinsic hazard of zinc slag wastes and the potential for the waste contaminants to be released into the environment, EPA ranked processed zinc slag and ferrosilicon as having a relatively high potential to pose a hazard to human health and the environment (compared to the other mineral processing wastes studied in this report). Therefore, the Agency used the model "Multimedia Soils" (MMSOILS) to estimate the ground-water, surface water, and air risks caused by the management of slag and ferrosilicon at the facility in Monaca, PA.

Ground-Water Risks

Using site-specific data with respect to contaminant concentrations, waste quantities, existing management practices, and hydrogeologic characteristics, EPA modeled potential releases to ground water from the processed slag and ferrosilicon piles at the Monaca facility. EPA considered in this analysis the potential releases of arsenic, cadmium, and selenium through the ground-water pathway based on the preceding analysis of processed slag and ferrosilicon leachate. In addition, the Agency modeled the risks caused by potential releases of lead to ground water, because lead concentrations measured in EP leach tests of both the slag and ferrosilicon exceeded the EP toxicity criterion.

The Agency's ground-water modeling results indicate that all four of these contaminants are likely to remain bound up in the unsaturated zone well beyond the modeling time frame considered (200 years). Once released from the base of the piles, EPA predicted that it would take arsenic, cadmium, and selenium 340 to 440 years to migrate through the unsaturated zone to the water table. EPA estimated that it would take over 10,000 years for any lead released from the piles to migrate to the water table. Therefore, the predicted risks associated with the release of these contaminants to the subsurface are effectively zero within the 200-year modeling horizon.

Surface Water Risks

To evaluate surface water risks, EPA estimated the concentrations of processed slag and ferrosilicon contaminants in the nearby Ohio River (located about 60 meters from the facility) after the contaminants have been fully mixed in the river's flow. EPA considered in this analysis the annual loading of contaminants to the river via ground-water seepage and erosion of small particles from the slag and ferrosilicon piles. The Agency predicted the surface water concentrations of the following constituents: arsenic, cadmium, copper, iron, lead, manganese, nickel, selenium, and zinc. For each constituent, the Agency compared the predicted concentrations to EPA-approved benchmarks for human health protection, drinking water maximum contaminant levels (MCLs), freshwater ambient water quality criteria (AWQC) for chronic exposures, and National Academy of Sciences recommended guidelines for irrigation and livestock waters.

Based on the Agency's modeling results, it appears that the very large average flow of the Ohio River near the Monaca site (23,000 mgd) is able to effectively assimilate chronic releases of contaminants from the processed zinc slag and ferrosilicon piles. EPA's predicted concentrations of each contaminant caused by releases from the slag and ferrosilicon were at least two orders of magnitude below the various criteria. This is true for predicted concentrations caused by releases from each waste independently, as well as total contaminant concentrations in the river resulting from aggregate releases from the two wastes. The predicted concentrations of arsenic, the only carcinogen modeled would pose a lifetime cancer risk of less than $2x10^{-9}$ (i.e., the chance of getting cancer would be less than two in one billion if the water was ingested over a 70-year lifetime). In every case, the contaminants were predicted to migrate to the Ohio River by run-off alone, not by seepage through ground water that discharges to the river.

Of the constituents that were modeled, only selenium is recognized as having the potential to biomagnify (concentrate in the tissues of organisms higher in the food chain). Even though the Agency predicted selenium concentrations that are well below the AWQC, there is a potential for selenium to biomagnify and cause adverse effects to wildlife at higher trophic levels. Cadmium, selenium, zinc, lead, and, to a lesser extent, arsenic can bioaccumulate in the tissue of freshwater fish that may be ingested by humans. However, even if an individual ingested 6.5 grams of fish[14] from the contaminated water every day of the year for 70 years, EPA estimates that cancer risks would be less than $1x10^{-9}$ and the doses of noncarcinogens would be below adverse effect thresholds.

Air Risks

EPA predicted the release of windblown dust from the processed slag and ferrosilicon piles, and the associated inhalation risks of the existing maximum exposed individual (located at a residence roughly 90 meters away in a south-southwest direction). EPA estimated the risks caused by windblown chromium, nickel, and selenium, through the inhalation pathway based on the preceding analysis of the wastes' composition. In general, the Agency's modeling approach was very conservative (i.e., tending to overpredict inhalation risks) because it was based on the assumption that there is an unlimited reservoir of fine particles that can be blown into the air from the zinc slag and ferrosilicon piles. As discussed previously, processed slag and ferrosilicon actually have limited wind erosion potential because the vast majority of the materials consists of large particles that are not suspendable or transportable in typical winds.

Even with this conservative approach, risks caused by the inhalation of dust from processed slag and ferrosilicon piles were predicted to be low. Specifically, at the residence of the maximum exposed individual, EPA predicted a total lifetime cancer risk of roughly $2x10^{-7}$ caused by the combined release of chromium and nickel from both wastes (the estimated inhalation risks caused by each waste individually were approximately the same, $8x10^{-8}$). Similarly, the predicted concentrations of selenium in air at the residence of the maximum exposed individual, caused by each waste individually and the two wastes together, were more than two orders of magnitude below the threshold concentration that could be associated with noncancer effects (dermatitis and gastrointestinal disturbances).

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[14] This is a typical daily fish intake averaged over a year (EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989).

14.3.2 Damage Cases

State and EPA Regional files were reviewed in an effort to document the environmental performance of zinc slag waste management practices at the active Monaca, PA smelter and four inactive zinc smelters.[15] The inactive primary zinc smelters included facilities in Columbus, Ohio and El Paso, Texas, last operated by ASARCO and facilities in DePue, Illinois and Palmerton, Pennsylvania operated by Zinc Corporation of America (ZCA). The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found that documented environmental damages associated with slag management had occurred at all three inactive smelters but not at the active facility.

ASARCO, Columbus, Ohio

The zinc smelter at Columbus, Ohio was owned by American Zinc Oxide from 1918 to 1970, at which time ASARCO purchased the property and operated it until ceasing production in 1986.[16,17] The facility produced zinc oxide from sphalerite ore by oxidation, reduction, and back oxidation.[18] Until recently, when ASARCO began selling its slag for further zinc recovery to Horsehead Resources,[19] it appears that all zinc slag was disposed and/or stored on-site. As of 1986, about 38,000 tons of zinc slag had been stored on the site in two primary slag piles: the northern pile, covering about 5 hectares (13 acres); and the southern pile, covering about 15 hectares (37 acres).[20,21]

Run-off from the facility drains to an open ditch near Joyce and 12th Avenues, referred to as the Joyce Ave. outfall. The receiving ditch, referred to as the American Ditch, flows about one mile through an industrial and residential area.[22,23] Until June 1989, when the American ditch was diverted to discharge directly to Alum Creek, flow from the American ditch entered the combined sewer of the city of Columbus.[24] Alum Creek, the present receiving stream, is classified as a primary contact, warm fishery, public, industrial, and agricultural water supply.[25]

In 1972, the City of Columbus found that its wastewater treatment facility was receiving excessive zinc and cadmium loadings from water originating at the ASARCO smelter site. Investigations eventually led to the conclusion that run-off and leachate from the on-site zinc slag were responsible for the excessive loading.[26] Water samples taken by the City of Columbus from the American Ditch, which bisects the facility, showed cadmium and zinc concentrations above limits established by the City. Dissolved cadmium measured 0.56 mg/L while dissolved zinc measures 92.0 mg/L; the recorded pH was 2.6.[27]

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[15] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

[16] City of Columbus. 1986. ASARCO Meeting. Representatives from Columbus Division of Sewerage and Drainage, Ohio EPA and ASARCO. October 30.

[17] Ohio Environmental Protection Agency. 1987. Inter-office communication from L. Korecko and C. Chao through W. McCarthy, CDO-DWPC, to R. Mehlhop, CDO-DWQMA, Re: Use Evaluation, Toxics Evaluation, Heavy Metals Allocation, etc. for ASARCO in Columbus. August 24.

[18] Ohio Department of Health. 1972. Untitled document concerning the history of the site and identification and solution of pollution problems. July 20.

[19] ASARCO. 1987. Letter from R. Marcus, Senior Environmental Scientist, to W. Schneider, Ohio EPA. January 30.

[20] City of Columbus, op. cit.

[21] ASARCO, op. cit.

[22] City of Columbus. 1981. Memorandum to R. C. Parkinson, Director of Public Service, through D.D. Robbins, Superintendent, from G. W. Newell, Manager of Surveillance, Re: American Ditch, ASARCO Pollution Problems. October 15.

[23] Ohio Environmental Protection Agency. 1981. Inter-Office Communication from K.A. Schultz, Chief, Emergency Response, to W.S. Nichols, Director, Re: "Acid Ditch' Complaint." October 20.

[24] Ohio Environmental Protection Agency. 1989. Letter from D. R. Parkinson, Division of Water Pollution Control, Ohio EPA, to R. Marcus, Senior Environmental Scientist, ASARCO. September 22.

[25] Ohio Environmental Protection Agency. 1974. Briefing memo. April 2.

A 1981 analysis performed by the City of Columbus on ASARCO's discharge to the American Ditch showed that the discharge exceeded by several times the 3.0 mg/L City limit for zinc and that cadmium concentrations were also above the 0.5 mg/L City limit.[28] ASARCO was cited by the City for violations of discharge limits for cadmium and zinc into the sewer system.[29]

Slag area run-off sampling data for September and October, 1986 revealed zinc concentrations of 26 mg/L and 46 mg/L, respectively. At that time, ASARCO agreed to begin removing the zinc slag from the facility.[30] In August 1987, the Ohio EPA described the situation at this facility by stating that, "[d]ue to past practices over many years of dumping waste slag or clinker all over the site, there is still a problem with contaminated run-off. There are documented problems with high concentrations of zinc and cadmium in the run-off."[31] In November 1987, ASARCO notified the City of its shipment off-site of 35,000 tons of zinc slag.[32]

Recent testing has shown that the release of contaminants into surface waters has continued. An Ohio EPA inter-office communication from June 1988 included a report which stated that "overall analysis of cadmium and zinc concentrations from the Joyce Avenue outfall [ASARCO's discharge to the American Ditch] suggests acutely toxic conditions exist on a frequent basis." For zinc, twenty percent of water samples (5 percent for cadmium) taken from the ASARCO treatment center outfall were reported to have exceeded the Final Acute Value limits (188 μg/L for cadmium and 1,298 μg/L for zinc) established for American Ditch to protect against rapidly lethal conditions within a water body.

ASARCO, El Paso, Texas

This facility contains combined deposits of lead, copper, and zinc slag. Heavy metal contamination of surface water and sediment in the Rio Grande River has been linked to these slag deposits. This situation is more fully described in Section 6.3.4, Damage Cases, for the copper sector.

Zinc Corporation of America, DePue, Illinois

Zinc Corporation of America's (ZCA) Illinois zinc plant is located just east of the Illinois River and Lake DePue, in Bureau County. The facility was originally owned by New Jersey Zinc Company, Inc. which later changed its name to Zinc Corporation of America. Its parent company is Horsehead Resources. From 1905 until 1966, New Jersey Zinc operated a zinc smelter, sulfuric acid plant, phosphoric acid plant and diammonium phosphate plant at this facility. In 1966, Mobil Chemical Company purchased all plants except the zinc smelter, which ZCA operated until 1971. Currently, there are approximately 26 employees producing zinc dust from zinc scrap.[33,34,35]

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[26] Ohio Environmental Protection Agency. 1974. Briefing memo. April 2.

[27] Ohio Department of Health. 1972. Note from J. Shea (sic) to F. Klengalhafed (sic), Re: Water Samples taken by City of Columbus from the ASARCO stream on the company's property. August 3.

[28] City of Columbus, 1981, op. cit.

[29] City of Columbus. 1981. Letter from R. C. Parkinson, Director, Department of Public Service, to N. S. Geist, Superintendent ASARCO. November 23.

[30] City of Columbus. 1986. ASARCO Meeting. Representatives from Columbus Division of Sewerage and Drainage, Ohio EPA and ASARCO. October 30.

[31] Ohio Environmental Protection Agency. August 24, 1987. Inter-office communication from L. Korecko and C. Chao through W. McCarthy, CDO-DWPC, to R. Mehlhop, CDO-DWQMA, Re: Use Evaluation, Toxics Evaluation, Heavy Metals Allocation, etc. for ASARCO in Columbus.

[32] The facility indicated that some slag (about 3,000 tons) had not been removed from the site due to possible PCB contamination resulting from a spill at an adjacent facility.

Zinc smelting wastes were deposited in one pile at the southern end of the site that covers approximately 10 acres and ranges in height up to 50 feet. In addition, there are also a number of smaller piles on the site which measure approximately 100 feet in length and 10 to 12 feet in height. These smaller piles may contain zinc slag in addition to other materials. Mobil Chemical Company did not purchase the land on which the slag piles are located and this property is still owned and controlled by Zinc Corporation of America.[36,37]

As early as 1967, the predecessor agency to the Illinois Environmental Protection Agency (EPA), the Illinois Sanitary Water Board, suspected rainfall run-off contamination from zinc slag piles located on New Jersey Zinc's property.[38] The Illinois EPA monitored the surface run-off and leachate from the zinc slag pile from 1973 to 1986. These analyses consistently showed levels of zinc, cadmium, copper, manganese, and lead in excess of the maximum contaminant levels for drinking water. For example, from March 5, 1973 to March 26, 1986, run-off samples which exceeded the established MCLs for drinking water from the slag pile ranged from 39 - 4000 mg/L for zinc (MCL = 5.0 mg/L); 0.5 - 3.6 mg/L for lead (MCL = .05 mg/L); 2.32 - 780 mg/L for manganese (MCL = 0.05 mg/L); 1.38 - 137.5 for copper (MCL = 1.3); and, 0.58 - 19.3 mg/L for cadmium (MCL = 0.01 mg/L). Run-off control measures (i.e., capping) have helped to reduce the levels of contaminant discharge. Surface water samples taken during April, May, and June of 1989 (after remedial controls were implemented at the facility) show the following range of concentration levels: zinc, 44.0 - 75.2 mg/L; lead, 0.05 - 0.06 mg/L; manganese, 1.8 - 3.83 mg/L; copper, 3.2 - 4.4 mg/L; and cadmium, 0.18 - .79 mg/L.[39,40,41,42,43,44]

Due to repeated problems in meeting effluent standards from this site, Zinc Corporation of America received a five-month discharge variance in April 1988, and a five-year extension to this variance in January 1989. Discharge monitoring reports submitted by the facility for the fourth quarter 1989 indicate that few

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[33] Illinois Environmental Protection Agency. December 11, 1975. Letter from B.J. Revak to D.R. Baker, NJZ, Re: The New Jersey Zinc Company (Bureau Country), Illinois Environmental Protection Agency File #2794.

[34] Illinois Environmental Protection Agency. July 12, 1982. NPDES Permit No. IL0052183 for the New Jersey Zinc Company, Inc., DePue, Illinois.

[35] Illinois Pollution Control Board. April 7, 1988. Order of the Borad regarding Petition for Variance of Consent Order.

[36] Illinois Environmental Protection Agency. December 11, 1975. Letter from B.J. Revak to D.R. Baker, NJZ, Re: The New Jersey Zinc Company (Bureau Country), Illinois Environmental Protection Agency File #2794.

[37] Illinois Pollution Control Board. op. cit.

[38] Illinois Environmental Protection Agency. May 12, 1977. Memorandum from D.P. Duffy to DWPC/FOS and Records Unit, Re: Mobil Chemical Company at DePue - Re: IL0032182 and New Jersey Zinc Company - IEPA File #2794.

[39] Illinois Environmental Protection Agency. March 5, 1973. Memorandum from L.W. Eastep to Division of Water Pollution Control, Surveillance Section, Re: New Jersey Zinc/Mobil Oil Company - Report of Operational Visit.

[40] Illinois Environmental Protection Agency. June 12, 1975. Memorandum from C.D. Miller to DQPC/FOS, Re: New Jersey Zinc - Mobil Chemical Company (DePue).

[41] Illinois Environmental Protection Agency. September 22, 1975. Memorandum from C.D. Miller to DWPC/FOS, Re: New Jersey Zinc - Sampling.

[42] Illinois Environmental Protection Agency. August 20, 1984. Memorandum from D.J. Connor to DWPC/FOS and Records Unit, Re: New Jersey Zinc - Sampling Visits.

[43] Illinois Environmental Protection Agency. June 9, 1986. Memorandum from D.J. Connor and H.J. Chien to DWPC/FOS and Records Unit, Re: New Jersey Zinc - Summary of findings.

[44] Horsehead Resources. July 21, 1989. Letter from D.P. Schoen to K. Rogers, Illinois Environmental Protection Agency, Re: Quarterly reports.

surface water contamination problems remained.[45] Monitoring data on the quality of ground water beneath the slag piles were not available.

14.3.3 Findings Concerning the Hazards of Zinc Slag and Ferrosilicon

Based on a review of available data on the composition of processed zinc slag and ferrosilicon, the wastes have seven to ten constituents present in concentrations that exceed the risk screening criteria. The contaminants that appear to present the greatest potential for concern in the two wastes are chromium, lead, manganese, and copper. Zinc concentrations in the processed slag, but not the ferrosilicon, could also conceivably pose risk under mismanagement scenarios. Based on available data and professional judgment, EPA does not believe either of the wastes exhibit the hazardous waste characteristics of corrosivity, reactivity, or ignitability. Lead concentrations measured in leachate from both wastes using the EP test frequently exceed the EP toxicity regulatory level. Using the SPLP test, however, neither of the wastes exceeded the EP toxicity regulatory levels.

Based on a review of existing waste management practices and predictive modeling results, EPA believes that processed zinc slag and ferrosilicon, as currently managed at the sole active zinc facility in Monaca, PA, pose an overall low risk to human health and the environment. The relatively high precipitation and ground-water recharge rates in Monaca, the permeable substrate, and the absence of liners or leachate collection systems combine to yield a high theoretical potential for contaminants to seep into the ground. However, the Agency predicts that metals leached from zinc slag and ferrosilicon at the Monaca facility would be largely bound to subsurface soil and would not reach ground water in the useable aquifer within 200 years. Similarly, there is a relatively high potential for slag and ferrosilicon contaminants to migrate into surface water because the facility is only 60 meters from the Ohio River, the annual precipitation is high, the slope of the land is relatively steep, and the waste management units lack stormwater run-off controls. The Ohio River, however, is very large and EPA predicts that it can readily assimilate the chronic loading of contaminants that is expected on a routine basis (the Agency's predicted annual average concentrations of contaminants in the river are at least two orders of magnitude below human health and environmental protection criteria). EPA's predicted concentrations of toxic constituents in the air caused by windblown dust from the waste management units also create very low risks at potential off-site exposure points.

The lack of documented cases of damage caused by the wastes at the Monaca facility supports the Agency's conclusion that zinc slag wastes at this facility pose a low risk. The two damage cases at inactive sites, however, demonstrate the potential for zinc slag to cause environmental problems when not managed properly. In particular, the damage cases demonstrate that the migration of contaminants from slag piles, especially contaminant migration via stormwater run-off, can cause surface water degradation when piles are maintained near small water bodies and not equipped with run-off controls.

14.4 Existing Federal and State Waste Management Controls

14.4.1 Federal Regulation

EPA is unaware of any federal management control or pollutant release requirements that apply specifically to zinc slag or ferrosilicon. EPA has promulgated effluent discharge limitations for the primary zinc smelting industrial category under authority of the Clean Water Act, but these regulations address wastewater discharges from wet air pollution control scrubbers and process sources, not slag storage or disposal (40 CFR 421). Federal air regulations applicable to zinc smelters apply to processing operations rather than waste management operations such as slag disposal.

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[45] Horsehead Resources. October 27, 1989. Letter from D.P. Schoen to K. Rogers, Illinois Environmental Protection Agency, Re: Quarterly reports.

14.4.2 State Regulation

The single zinc processing facility currently active in the United States that generates smelting slag is located in Monaca, Pennsylvania. Rather than regulating zinc slag as either a hazardous or solid waste, the state of Pennsylvania addresses zinc slag under its "residuals" regulations. Proposed revisions to the state's residuals regulations would require a substantial expansion in the scope of the management controls for zinc slag disposal. The proposed rule also would require that the owners/operators certify that they have attempted to reuse and/or recycle the waste before disposal, but apparently would not specify environmental controls for the reuse of the materials. The current residuals rule imposes only limited permitting requirements. For instance, although waste piles for permanent disposal must be permitted under current state residuals regulation, Pennsylvania effectively has not implemented this requirement for slag piles because of disagreements with industry on the status (i.e., storage versus disposal) of the piles. The state has not required that the Monaca plant obtain a permit for its slag piles. Similarly, the state applies surface water and air (i.e., fugitive dust control) requirements on a case-by-case basis and generally in response to complaints or evidence of environmental damage only. In summary, although the proposed residuals rule would impose notably more stringent environmental controls on the management of zinc slag than the state currently requires, the exact nature and extent of such controls cannot be predicted pending adoption and implementation of a final rule.

14.5 Waste Management Alternatives and Potential Utilization

The ZCA Monaca facility processes all of the slag emerging from the furnace (see section 14.2) to isolate those portions that can be returned to the production process or otherwise utilized. The slag is separated into four materials: reclaimed coke and zinc-rich fines, which are both recycled; ferrosilicon, which is stockpiled until it can be sold to cast iron manufacturers; and processed slag, which may be disposed in a slag pile or used is the facility's flyash landfill or in construction applications.

14.5.1 Waste Management Alternatives

The amount of zinc slag that is recycled can vary, depending on the amount of zinc and coke contained in the slag. The amount of zinc and coke in the slag is largely a function of how efficiently the retort furnace utilizes the feed materials, and the nature and quality of the ore and secondary materials being fed to the smelting process. Both the retort furnace efficiency and feed materials can vary considerably from run to run, and the facility adjusts the amount of zinc slag being returned to the process to extract the maximum amount of zinc from the inputs (96-97 percent).[46] Consequently, there is little potential for further reducing the amounts of waste slag being generated by increasing recycling efforts.

14.5.2 Utilization

In 1988, 17,000 and 28,000 metric tons of ferrosilicon and processed slag, respectively, which were separated from the slag removed from the furnace, were sent to on-site storage/disposal piles. During the same period, however, 32,500 metric tons of processed slag were removed from the slag piles for utilization. While none of the ferrosilicon was sold in 1988, sales before and after 1988 have been reported.[47] This information, along with the relatively small on-site accumulations of ferrosilicon (48,000 metric tons) and processed slag (63,500 metric tons) suggest that much of the zinc slag that cannot be recycled is being utilized in the ways discussed below.

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[46] Personal communication, James D. Reese, Director of Environmental Affairs, Zinc Corporation of America, April 20, 1990.

[47] Ibid.

Utilization of Ferrosilicon to Produce Cast Iron

The ferrosilicon, which is magnetically separated from the rest of the zinc slag, is occasionally sold to cast iron foundries as a source of iron. The amount of ferrosilicon sold to produce cast iron is largely a function of the technical requirements of the cast iron producers and the relative prices of ferrosilicon and scrap steel (competing materials). The 1988 slump in sales of ferrosilicon are attributed to the ferrosilicon being over-priced. ZCA has since lowered the price of ferrosilicon and sales have increased.[48]

Utilization of Processed Slag as Drainage Material in Landfills

The processed slag is currently being used as a drainage material in the flyash landfill at the Monaca facility. The flyash is generated by two 60 megawatt power plants that are located on-site and produce power for the facility. The processed slag has been placed in a layer on the bottom of the flyash landfill and covered with fabric (to prevent clogging by the flyash) before any flyash is added. In 1988, the facility used 27,000 metric tons of its processed slag in this fashion. ZCA also uses the two medium-sized fractions of processed slag as a cover material to reduce dust from the flyash landfill. This practice was only recently begun, however, so it has not yet been determined how much slag will be used in this way.

The use of processed zinc slag as a drainage material in flyash landfills should be at least as protective of human health and the environment as disposing it in a slag pile. If the water captured by the leachate collection system is treated to remove any constituents of concern or the slag serves to remove contaminants from any flyash leachate, this practice should prove to be more protective of human health and the environment than disposal in one of the slag piles (which do not have leachate collection/treatment systems).

Processed Slag as Railroad Ballast and Road Rock

Zinc slag from the Monaca facility has also been utilized as railroad ballast and road rock (gravel).[49,50,51] Approximately 23,900 metric tons of zinc slag were sold as railroad ballast in 1982 and 5,500 metric tons of processed slag were sold as gravel for roads, driveways, and parking lots in 1988.[52,53] No information has been found to indicate that future levels of use will greatly exceed the current 5,500 metric tons per year. It should be noted that only the two medium-sized fractions of processed slag are of the preferred size for these applications.

With one exception, EPA believes that the use of processed slag as railroad ballast or road rock poses risks comparable to those stemming from its disposal in slag piles. The exception is that use as road rock will increase the potential for airborne releases of slag dust. The basis for this belief is that when the slag is used on roads or driveways, it will be in closer proximity to people, and will also be subjected to crushing and dust entrainment by passing vehicles. EPA does not, however, have sufficient information to determine whether this is a significant concern.

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[48] Ibid.

[49] PEI Associates, Inc., 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Zinc Smelting and Refining, prepared for U.S. Environmental Protection Agency, Office of Reaserch and Development, Cincinnati, Ohio, Contract No. 68-03-3197, Work Assignment No. 3.

[50] Zinc Corporation of America, 1989(a), op. cit.

[51] Reese, op. cit.

[52] PEI Associates, Inc., op. cit.

[53] Zinc Corporation of America response to EPA, 1989(a), op. cit.

Utilization as an Aggregate in Asphalt Manufacturing

Processed zinc slag has been used as an aggregate in asphalt and as an anti-skid material, though tests performed at Oklahoma State University on four types of zinc smelter slag indicate that it is not suitable for use as an aggregate in portland cement concrete because of alkali-aggregate activity.[54] ZCA reported that while none of its processed slag is currently being sold as aggregate for asphalt, the technical suitability of and markets for the material are being investigated.[55]

It is not expected that using processed zinc slag as an aggregate in asphalt will alter the chemical composition of the slag, but the potential for any of the slag constituents to enter the environment via leachate or dust is expected to be less than for use as road rock or disposal in a slag pile.

14.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if land disposal restrictions had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, requirements that might apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted-average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S. Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed by the affected primary zinc producer under different regulatory scenarios. Next, the Agency discussed the cost implications of requiring these changes to existing waste management practices. The last part of this section predicts and discusses the ultimate impacts of the increased waste management costs faced by the affected zinc facility.

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[54] Collins, R.J. and R.H. Miller, Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis, FHWA-RD-76-106, prepared for Federal Highway Administration, May 1976, pp. 168-170, 178, 196, and 210.

[55] Reese, op. cit.

14.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented earlier in this chapter, EPA believes that zinc slag poses an overall low risk to human health and the environment. Nonetheless, the special waste exhibits the hazardous waste characteristic of EP toxicity. Accordingly, the Agency has estimated the costs associated with regulation under Subtitle C of RCRA, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus," as previously introduced in Chapter 2, and as described in specific detail below. The Agency's cost and impact analysis is limited to the single pyrometallurgical primary zinc processor, the ZCA facility in Monaca, Pennsylvania.

In the following paragraphs, EPA discusses the assumed management practices that would occur under each regulatory alternative.

Subtitle C

Under Subtitle C standards, hazardous waste that is managed on-site must meet the standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because zinc slag and its residues are solid, non-combustible materials, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed in waste piles, EPA has assumed in this analysis that the ultimate disposition of processed zinc slag and ferrosilicon would be in Subtitle C landfills. Because, however, current practice at the Monaca facility is storage and/or disposal of these materials in waste piles, the Agency has assumed that the facility would also construct a temporary storage waste pile (with capacity of one week's waste generation) that would enable the operators to send the processed slag and ferrosilicon to on-site disposal efficiently. EPA has assumed that the Monaca plant could not continue to sell or utilize the ferrosilicon and processed slag as it does currently, and would dispose the total quantities of these materials in a lined landfill. EPA believes that, because of cost considerations, ZCA would construct one on-site landfill that meets the minimum technology standards specified at 40 CFR 264, rather than ship the material off-site to a commercial hazardous waste landfill or build multiple landfills.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-minus is the facility-specific application of requirements based on potential risk from the hazardous special waste. Under the C-minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating groundwater resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) would be necessary to protect human health and the environment. The Monaca facility was determined to have a low potential to contaminate groundwater resources. Therefore, under the Subtitle C-Minus scenario, the facility would be allowed to continue to operate its present storage waste piles, though run-on/run-off and wind dispersal/dust suppression controls are assumed to be required for the units. In addition, the storage units must undergo formal closure; they are assumed to be "clean closed" with all inventory removed.

While under baseline conditions the ultimate disposition of processed slag and ferrosilicon is periodic sale for utilization (i.e., not recycling); under this regulatory scenario EPA has assumed that neither material could be utilized in this way due to its intrinsic hazardous waste characteristics. Therefore, the facility is assumed to be required to operate a disposal waste pile. Because the facility is located in a low risk area, the unit would not require a liner and could be capped with a simple revegetated soil layer at closure. Run-on/run-off controls and groundwater monitoring would be required; both practices would continue during the 30 year post-closure care period.

Subtitle D-Plus

As under both Subtitle C scenarios, the facility operator would, under the Subtitle D-plus scenario, be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-

Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to ground water increases. As the Monaca facility has low potential to contaminate ground-water resources, the facility is assumed to be allowed to continue operating its storage waste piles under the Subtitle D-Plus scenario. The waste piles would be retrofitted with run-on/run-off and wind dispersal/dust suppression controls which, as under Subtitle C-Minus, must be maintained through closure and the post-closure care period. While under baseline the ultimate disposition of ferrosilicon was sale for off-site utilization (i.e., not recycling), under the Subtitle D-Plus regulatory scenario the waste (with its intrinsic hazard) could not be sold for off-site use. Therefore, the facility is assumed to be required to operate a waste pile for disposal of the ferrosilicon. As the unit is located in a low risk area, this disposal waste pile would not require a liner; ground-water monitoring and capping at closure is assumed to not be required for management units under Subtitle D-Plus when the ground-water contamination potential is low, although wind dispersal/dust suppression controls must be maintained.

14.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the Monaca zinc smelter are presented for each regulatory scenario in Exhibit 14-6. Under the full Subtitle C scenario, ZCA's annualized regulatory compliance costs are estimated to be just under $5 million more than the baseline waste management costs (about 195 times greater). Two thirds ($3.2 million) of the increased compliance costs would be for new capital expenditures.

Under the facility specific risk-related requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about 72 percent less than the full Subtitle C costs. ZCA's annualized compliance costs would be $1.4 million more than the baseline waste management costs (about 55 times greater). The primary savings over the full Subtitle C costs, due to the consideration of risk potential, are the relaxation of technical requirements and the ability to use disposal wastepiles. New capital expenditures, nearly 83 percent less than under full Subtitle C, would account for about $555,000 of the incremental C-Minus compliance costs (about 40 percent of the annualized compliance cost).

Regulation under the Subtitle D-Plus program is assumed to require the same management controls as under Subtitle C-minus, with the exception that, because of the low risk classification, no ground-water monitoring or capping at closure is required under this scenario. ZCA's annualized regulatory compliance costs would be $1.1 million more than the baseline waste management costs. This represents an increase of about 42 times over baseline, but a decrease of 78 percent from the Subtitle C compliance costs, and a decrease of 23 percent from estimated Subtitle C-Minus compliance costs.

14.6.3 Financial and Economic Impact Assessment

To evaluate the ability of the affected facility to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of the facility (in the form of financial impact ratios) to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary producers of zinc. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts which would have to be absorbed by ZCA. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in Appendix E-4 to this document.

Exhibit 14-6
Compliance Cost Analysis Results for Management of Zinc Slag from Primary Processing[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Zinc Corporation of America - Monaca, PA	25	4,922	21,978	3,279	1,377	3,717	555	1,058	3,467	517
Total:	25	4,922	21,978	3,279	1,377	3,717	555	1,058	3,467	517

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.

Financial Ratio Analysis

Screening analysis of the financial ratios indicates that regulation of zinc slag under full Subtitle C would have a potentially significant financial impact on the ZCA facility. As shown in Exhibit 14-7, annualized compliance costs exceed five percent of value of shipments and eleven percent of value added. Annualized compliance capital represents a full 45 percent of the average sustaining capital needed annually.

Under the Subtitle C-Minus and D-Plus scenarios, impacts are substantially less and only marginally significant. Annual compliance costs as a percent of value of shipments is less than 1.5 percent under either scenario; the percent of those costs to value added are 2-3 percent under the two scenarios. Under both scenarios the annualized compliance capital is between 7 and 8 percent of the annual sustaining capital investments.

Market Factor Analysis

General Competitive Position

In 1987, a total of 342,663 metric tons of slab zinc was produced by the four domestic zinc-producing facilities; three facilities (which do not produce a special waste) used the electrolytic technique, and one facility (ZCA-Monaca, which produces a special waste) used the pyrometallurgical technique. Domestic metal production in 1988 was near annual capacity (approximately 400,000 metric tons). Strong demand and high prices are expected to result in growth rates throughout the 1990's of 0-2.5 percent in the U.S., and greater than 2.5 percent globally. The opening of one zinc mine in Idaho and the anticipated opening of two more in Alaska are an indication that domestic zinc mine output will remain high. Secondary production has increased steadily over the past five years from a low of 63,000 metric tons to an estimated 110,000 metric tons in 1989; this sub-sector is expected to continue to meet a large portion of the domestic demand for zinc.

Domestic zinc consumption in 1988 rose in virtually all use categories, led by increases in galvanizing and electro-galvanizing, and resulted in record-high imports of both slab zinc and zinc oxide. Both domestic and global consumption of zinc are expected grow more than 2.5 percent per year throughout the 1990's.

Exhibit 14-7
Significance of Regulatory Compliance Costs for Management of Zinc Slag from Primary Processing[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Zinc Corporation of America - Monaca, PA	5.1%	11.4%	45.4%
Subtitle C-Minus			
Zinc Corporation of America - Monaca, PA	1.4%	3.2%	7.7%
Subtitle D-Plus			
Zinc Corporation of America - Monaca, PA	1.1%	2.4%	7.2%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based on EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Potential for Compliance Cost Pass-through

Labor Markets. Approximately 2,100 people are employed in the mining and milling of zinc, and 1,500 people are employed in primary zinc smelting. No other information is currently available.

Lower Prices to Suppliers. While it may be possible to pass along a portion of increased costs to suppliers, the partial integration of the zinc producers and zinc ore mines make it unlikely that very much of the cost could be passed backwards.

Higher Prices. U.S. "High Grade" zinc currently costs about 5 cents more than its "Prime Western" equivalent, indicating that an increase in U.S. prices would be infeasible without an equivalent rise in the world price of zinc. However, with the currently tight supply-demand situation, world reserves of zinc have fallen, resulting in record-high prices during the last quarter of 1988. Therefore, it appears that any affected U.S. companies might be able to pass on somewhat higher costs in the form of higher prices if current consumption trends continue.

Evaluation of Cost/Economic Impacts

Given the severe cost impacts which would be experienced by ZCA under full Subtitle C, and the limited potential for long-term compliance cost pass-through, EPA believes that regulation of zinc slag under full Subtitle C regulations would pose a threat to the economic viability of the ZCA facility. The estimated compliance costs represent significant portions of the value added by zinc processing operations at the Monaca plant, would be expected to exceed ZCA's operating margins, and would likely force ZCA to discontinue operating the Monaca facility, at least as a primary zinc smelter.

Prospective impacts under Subtitle C-Minus regulation and, to a greater extent, under D-Plus regulation, would be marginally significant at worst, as demonstrated by the results of the financial ratio screening analysis. In addition, ZCA occupies a unique market niche as the only primary zinc processor with smelter operations that can utilize scrap and other secondary materials which are not readily recoverable in electrolytic zinc plants, as feedstocks, and ZCA/Monaca's upgraded energy efficient electrothermic furnaces (installed in 1980) have served to lower production costs in recent years. Therefore, EPA believes that the facility would be able to incur the estimated costs and continue operating in the currently strong zinc market. If current zinc prices remain strong, ZCA might be able to raise prices sufficiently to offset some or all of its compliance costs, at least in the short term. As an alternative, ZCA might also further process its ferrosilicon in order to reduce its potential toxicity, thereby allowing sale for reprocessing. As a final option, ZCA could adopt the practices of other smelter operations and shift to secondary processing, thereby decreasing or eliminating the fraction of ore comprising its feedstock, and, presumably, reducing the generation rate of its slag. In any case, EPA expects that regulation under the Subtitle C-Minus or D-Plus regulatory scenarios would not significantly affect the facility or threaten its continued economic viability.

14.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of processed slag and ferrosilicon from zinc processing is relatively high compared to other mineral processing wastes studied in this report. Based on EP leach test results, 25 out of 36 samples of processed slag and 1 out of 1 sample of ferrosilicon from the Monaca facility contain lead concentrations in excess of the EP toxicity regulatory levels. Lead concentrations measured in SPLP (EPA Method 1312) leachate, however, were well below the EP regulatory levels. In addition, processed zinc slag contains five constituents in concentrations that exceed the conservative screening criteria used in this analysis by more than a factor of 10. Ferrosilicon contains four constituents in concentrations greater than 10 times the conservative screening criteria.

Based on a review of existing waste management practices and predictive modeling results, EPA believes that processed zinc slag and ferrosilicon, as currently managed at the active zinc facility in Monaca, PA, pose an overall low risk to human health and the environment. The relatively high precipitation and ground-water recharge rates in Monaca, the permeable substrate, and the absence of liners or leachate collection systems combine to yield a high theoretical potential for contaminants to seep into the ground. However, the Agency predicts that metals leached from zinc slag and ferrosilicon at the Monaca facility would be largely bound to subsurface soil and would not reach ground water in the useable aquifer within 200 years. Similarly, there is a relatively high potential for slag and ferrosilicon contaminants to migrate into surface water because the facility is only 60 meters from the Ohio River, the annual precipitation is high, the slope of the land is relatively steep, and the waste management units lack stormwater run-off controls. The Ohio River, however, is very large and EPA predicts that it can readily assimilate the chronic loading of contaminants that is expected on a routine basis (the Agency's predicted annual average concentrations of contaminants in the river are at least two orders of magnitude below human health and environmental protection criteria). EPA's predicted concentrations of toxic constituents in the air caused by windblown dust from the waste management units also create very low risks at potential off-site exposure points.

The lack of documented cases of damage caused by the wastes at the Monaca facility supports the Agency's conclusion that zinc slag wastes managed at this facility pose a low risk. The damage cases at inactive sites, however, demonstrate the potential for zinc slag to cause environmental problems when not managed properly. In particular, the damage cases demonstrate that the migration of contaminants from slag piles, especially contaminant migration via stormwater run-off, may cause significant surface water degradation when piles are maintained near small water bodies and not equipped with run-off controls. (Although some of the management units at the Monaca Plant are not equipped with run-off controls, surface water impacts are limited by the large flow of the Ohio River.)

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

Although zinc slag wastes are expected to maintain a relatively high intrinsic hazard in the future, the waste management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment at the Monaca facility are expected to continue to limit risks in the future in the absence of Subtitle C regulation. The characteristics of these wastes are unlikely to change in the future, and no new zinc smelters that would produce these wastes are expected to commence operation in the near future. A portion of the zinc slag is sold for use at off-site locations as road gravel or construction aggregate, and ferrosilicon is stockpiled until it can be sold for off-site use as a source of iron. Because these off-site locations could be conducive to releases and risks at present and in the future, this analysis of the potential and documented dangers of these wastes at the Monaca facility may underestimate the risks associated with these wastes at other locations. EPA is concerned that some types of slag and ferrosilicon utilization may not be protective of human health and the environment and plans to investigate methods to ensure that all slag uses are protective.

At this time, Pennsylvania does not regulate zinc slag wastes as either hazardous or solid wastes. Rather, the state addresses zinc slag under its "residuals" regulations. The current residuals rule imposes only limited permitting requirements, and the state has not required that the Monaca facility obtain a permit for its slag piles. Moreover, the State applies surface water and fugitive dust control requirements on a case-by-case basis and generally only in response to complaints or evidence of environmental damage. Proposed revisions to the state's residuals rule, however, would require a substantial expansion in the scope of the management controls for zinc slag disposal. The revised rule also would require that the owners/operators certify that they have attempted to reuse and/or recycle the waste before disposal, but apparently would not specify environmental controls for the reuse of the materials. It is not clear at this time how the rule may address inactive or abandoned units.

Costs and Impacts of Subtitle C Regulation

Because EPA waste sampling data indicate that processed slag and ferrosiliicon from the Monaca facility may exhibit the hazardous waste characteristic of EP toxicity, the Agency has evaluated the costs and associated impacts of regulating these materials as hazardous wastes under RCRA Subtitle C. As with the other aspects of this study, the Agency's cost and impact analysis is limited in scope to the facility at Monaca, PA.

Costs of regulatory compliance approach $5 million annually under the full Subtitle C regulatory scenario, while regulation under the more flexible standards of the Subtitle C-Minus scenario imply compliance costs of about $1.4 million annually, a reduction of 72 percent over full Subtitle C costs. Incremental costs under the Subtitle D-Plus scenario are just over $1 million annually. Subtitle C costs represent a significant fraction (more than eleven percent) of the value added by the Monaca operation, and would require capital expenditures exceeding 45 percent of the annual capital currently required to sustain production at this facility. Estimated Subtitle C-Minus and Subtitle D-Plus costs are estimated from one to three percent of the value of shipments of and value added by the facility. EPA's economic impact analysis suggests that the operator of the potentially affected facility (ZCA) would have only a limited ability to pass through a portion of any regulatory compliance costs that it might incur to product consumers. Because of competition from other, unaffected zinc producers, both domestic and foreign. Because of these factors, EPA believes that a decision to regulate slag from primary zinc production under RCRA Subtitle C could adversely affect the ability of the Monaca facility to continue to compete successfully over the long-term, while the estimated costs associated with the Subtitle C-Minus and D-Plus scenarios are not likley to result in significant impacts.

Finally, EPA believes that incentives for recycling or utilization of zinc slag would be mixed if a change in the regulatory status of this waste were to occur. In-process recycling is the current managment practice that is applied to zinc slag. It is possible that tighter regulatory controls on the management of primary zinc slag and its residues might serve to promote even greater recycling and on-site utilization than has occurred in the recent past. Utilization of processed zinc slag in construction and other off-site applications has been reported, but is not widely practiced at present, while utilization of ferrosilicon as a feedstock for producing cast iron by foundries has been occurring for some time. It is likely that removing zinc slag from the Mining Waste Exclusion and thereby subjecting it to regulation as a hazardous waste would, in practical terms, eliminate the off-site use of processed slag in construction applications, and of ferrosilicon as a source of iron in cast iron foundries.

Glossary[1]

Acid Plant Blowdown: Waters that have been used in an acid plant and that have accumulated contaminants to such an extent that they are removed from the system.

Acute Exposure: Exposure to a substance for a short period of time.

Adsorption Coefficient (K_d): A measure of the degree to which constituents bind to a material (e.g., the soil).

Aggregate: A rock material such as sand, gravel, or crushed rock with which cement or bitumen is mixed to form a mortar or concrete.

Alkaline: A synonym for basic (i.e., pH greater than 7).

Alumina: Aluminum oxide, Al_2O_3, an important constituent of all clays, determining their suitability for firebrick and furnace linings; also, used in granular form for abrasive purposes.

Amalgamation: The process by which mercury is alloyed with some other metal to produce an amalgam.

Ambient: The area surrounding the facility or residual management unit. "Ambient" monitoring data refers to pollutant measurement data from the medium (e.g., air, surface water) to which the pollutants are discharged, not to measurements of the discharge itself.

Anhydrous: Minerals which do not contain water in chemical combination.

Anode: The positive electrode in an electrolytic cell.

Anode Copper: Special-shaped copper slabs, resulting from the refinement of blister copper in a furnace, used as anodes in electrolytic refinement.

Anode Metals: Metals (e.g., copper) used for electroplating. They are as pure as commercially possible, uniform in texture and composition, and have the skin removed by machining.

Aquifer: A subsurface formation containing water in quantities sufficient to be withdrawn.

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[1] Many of the glossary definitions are taken from the Dictionary of Mining, Mineral, and Relating Terms, compiled and edited by P.W. Thrush and Staff of the Bureau of Mines, U.S. Dept. of the Interior, Bureau of Mines, 1968.

Baghouse: Chamber in which exit gases (e.g., from roasting, smelting, and calcining) are filtered through membranes (bags) which arrest solids.

Bauxite: A mineral composed of one or more aluminum hydroxides (e.g., boehmite, gibbsite, and diaspore) and impurities such as silica, clay, silt, and iron hydroxide; essentially, $Al_2O_3 \cdot 2H_2O$. A clay containing much bauxite should be termed bauxite.

Beneficiation: The following activities: crushing, grinding, washing, dissolution, crystallization, filtration, sorting, sizing, drying, sintering, pelletizing, briquetting, calcining to remove water and/or carbon dioxide, roasting in preparation for leaching, gravity concentration, magnetic separation, electrostatic separation, flotation, ion exchange, solvent extraction, electrowinning, precipitation, amalgamation, and heap, dump, vat, tank, and *in situ* leaching.

Bleed Electrolyte: Electrolyte from electrolytic metal refining that has accumulated contaminants to such an extent that it must be removed from the system.

Blister Copper: An impure (98.5 - 99.5 percent) intermediate product in the refining of copper, produced by blowing copper matte in a converter, the name being derived from the large blisters on the cast surface that result from the liberation of SO_2 and other gases.

Brine: Water with a high (e.g., greater than sea water) salt concentration.

Briquetting: A process by which coke breeze, coal dust, iron ore, or other pulverized mineral commodities is bound together into briquettes, under pressure, with or without a binding agent such as asphalt.

By-Product Manufacturing Unit: A management unit that receives a residual as a feedstock and produces a saleable product or intermediate product.

Calcination: Heating an ore or mineral product or intermediate product in a furnace or kiln to decompose carbonates, hydrates, or other compounds to produce a final product. The process is different from roasting in that air is not supplied to the charge during heating.

Cancer Risk: The estimated probability of occurrence of cancer in an individual, over that individual's lifetime.

Capacity: The maximal annual output of a particular processing operation, irrespective of market conditions. This limit may be determined by either design constraints or permit limitations.

Carcinogen: A chemical for which there is sufficient evidence that it can cause cancer in humans.

Cathode: The negative electrode in an electrolytic cell.

Cementitious: Having the property of or acting like cement (see Pozzolanic) (e.g., certain limestones and tuffs when used in the surfacing of roads).

Chemical Conversion: A mineral processing operation in which an ore or mineral or beneficiated ore or mineral is treated with one or more chemicals in order to initiate a reaction that liberates and/or changes the chemical form of the ore value(s). Examples include sulfuric acid digestion of phosphate ore and of titanium ore.

Chronic Exposure: Exposure to a substance over a long period of time.

Closure Plan: A written plan that identifies and describes the steps that will be carried out to close, dismantle, decommission, and/or reclaim a residuals management unit at a mineral processing facility.

Constituent: A chemical or radiological agent (e.g., arsenic or radium-226) present in a waste.

Corrosivity: One of the four characteristics of hazardous waste as defined by EPA, based upon pH values of less than 2.0 or greater than 12.5 (see 40 CFR §261.22).

Crushing: Reducing ore by stamps, crushers, or rolls.

Cryolite: A halide mineral, $Na_3Al \cdot F_6$, used in the reduction of aluminum ore.

Crystallization: The process through which crystalline phases separate from a fluid.

Cutoff Grade: The lowest grade of mineralized rock that qualifies as ore in a given deposit.

Dewatering: The removal of water from a material by pumping, drainage, filtration, or evaporation.

Dissolution: The process of dissolving or breaking up into a liquid.

Dolomite: A carbonate of calcium and magnesium, $CaMg(CO_3)_2$.

Down Gradient: The direction of ground-water flow caused by difference in hydraulic head at two locations (from the highest to the lowest hydraulic head).

Dross: The scum that forms on the surface of molten metals largely because of oxidation but sometimes because of the rising of impurities to the surface.

Drying: The removal of water from ores, concentrates, fluxes, or other materials.

Dump Leaching: A beneficiation operation most often used to extract metal values from subore-grade materials in the copper industry, in which dilute acid or water is percolated through piles of low grade ore or tailings. The dilute metal solution generated is collected at the bottom of the pile (dump), and is subjected to one or more downstream extraction operations to recover the metal values.

Effluent: A liquid, solid, or gaseous product, frequently waste, discharged or emerging from a process.

Electrogalvanizing: The electroplating of zinc upon iron or steel.

Electrolyte: A substance that when dissolved in a suitable solvent or when fused becomes an ionic conductor.

Electrolytic: Pertaining to the use of electrolysis; applied to the refining of metals by deposition from solution.

Electrostatic Separation: A method of separating materials by dropping feed material between two electrodes, positive and negative, rotating in opposite directions. Nonrepelled materials drop in a vertical plan; susceptible materials are deposited in a forward position somewhat removed from the vertical plane.

Electrowinning: The process of refining copper or other metals by the dissolution of the metal bearing ore in an acidic solution, the introduction of the solution as an electrolyte in an electrolytic cell, and the deposition of the metal from solution by application of electric current.

Endangered Species Habitat: The natural surroundings of any plant or animal that is considered endangered or threatened by federal or state governments.

EP Toxicity (Extraction Procedure Toxicity): One of four characteristics of hazardous waste as defined by EPA (see 40 CFR §261.24). Materials that are shown to leach one or more of 14 hazardous constituents at concentrations exceeding 100 times primary drinking water standards are considered EP toxic. These constituents include arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP Silvex.

Exposure Pathway: The way a chemical or physical agent comes into contact with humans or the environment.

Extraction: The process of mining and removing ores or minerals from the ground.

Facility: All mining, beneficiation, processing, fabrication/manufacturing, and residuals management units within property boundaries controlled by one operating company.

Fault Area: A geographic region of any size that has been seismically active (i.e., has had displacement or movement) during holocene time (approximately the last 11,000 years).

Ferrosilicon: An alloy of iron and silicon, used in steel and corrosion-resistant cast iron.

Filtration: A process for separating solids from liquids by allowing the liquid to pass through a material which retains the solids.

Floodplain: The portion of a river valley, adjacent to the river channel, that is built of sediments during the present regimen of the stream and which is covered with water when the river overflows its banks at flood stages.

Flotation: See Froth Flotation.

Fluorogypsum: See Gypsum.

Froth Flotation: A floatation process in which the minerals floated gather in and on the surface of bubbles of air or gas driven into or generated in the liquid in some convenient manner.

Fuming: A process whereby fine particles are dispersed in a gaseous phase prior to recovery in condensers; used in the recovery of zinc from the slag generated in lead smelting.

Gravity Concentration: Separating grains of minerals by a concentration method operating by virtue of the differences in density of various mineral; the greater the difference in density between two minerals, the more easily they can be separated.

Grinding: Size reduction into relatively fine particles.

Ground-Water: Water contained within a subsurface formation.

Gypsum: A common evaporite mineral, $CaSO_4$, with a variety of uses in construction materials and agriculture. Mined gypsum is generally referred to as natural gypsum, whereas gypsum produced by the neutralization of sulfuric acid from phosphoric acid or hydrofluoric acid production is referred to as phosphogypsum and fluorogypsum, respectively. Depending on temperature, pH, and the availability of water, gypsum can exist in a variety of forms: anhydrite, $CaSO_4$; hemihydrate, $CaSO_4 \cdot \frac{1}{2}H_2O$; and dihydrate, $CaSO_4 \cdot 2H_2O$.

Gypsum Stack: A residuals management unit that is used to store or dispose of the gypsum produced by acidulation of phosphate rock or feldspar. Active stacks will generally be used for water management as well as gypsum disposal.

Heap Leaching: A beneficiation process in which low grade ore containing valuable metals is piled on an impervious surface (pad) then treated with water or a dilute solution (often containing cyanide). The solution preferentially dissolves metals, such as gold and silver, which are recovered by collecting the solution and extracting the metals.

Hydrolysis: The formation of an acid and a base from a salt by interaction with water.

Hydrometallurgy: Recovery of metals from ores by a liquid process such as leaching with acid, or solvent extraction.

Ignitability: One of the four characteristics of a hazardous waste as defined by EPA (see 40 CFR §261.21), based upon the ability to combust at or near 140 degrees, or to cause fire through friction, or if it is an ignitable compressed gas, or is an oxidizer.

Ilmenite: An iron black mineral, $FeO \cdot TiO_2$.

Intermediate: A material produced during the beneficiation or processing of materials, ores, and minerals and which are further processed to recover a usable product or returned to the original process or processes and reused in the production process.

Intrinsic Hazard: The ability of a chemical to harm humans or the environment, [illegible] of release and exposure are assumed to occur.

Ion Exchange: The reversible exchange of ions contained in a crystal for different ions in solution without destruction of crystal structure or disturbance of electrical neutrality.

Leachate: A solution formed by dissolving the soluble fraction of a waste or ore into a liquid.

Leaching: The dissolution of chemical constituents from an ore, mineral, beneficiated ore or mineral, or processed ore or mineral by applying water or a solution to the material

Lignite: A soft brownish-black coal in which the alteration of vegetal material has proceeded further than peat but not so far as subbituminous coal.

Lime: Quicklime (CaO) obtained by calcining limestone or other forms of calcium carbonate.

Liner: A material used in sealing the bottoms of residual management units so as to prevent leakage of contaminants into the environment. Liner materials range from bedrock and in-situ clay to synthetic plastics.

Magnetic Separation: The separation of materials from nonmagnetic materials using a magnet.

Matte: A metallic sulfide mixture made by the smelting of sulfide ores of copper, lead, and nickel.

Maximally Exposed Individual (MEI): An individual designated for each exposure pathway, to be at the greatest risk to constituents released to the environment.

Milling: The process of grinding or crushing ores into fine fractions for removal of valueless or harmful constituents.

Mining: The minerals industry which supplies the community with coal, minerals, or metal raw materials and includes production of primary products, for example, copper from porphyry copper ore.

NESHAP (National Emission Standards for Hazardous Air Pollutants): Air pollutant emission standards for specific contaminants that have been shown to be dangerous to human health.

Oölite: Limestone rock (calcium carbonate) of the Jurassic system consisting of small round grains, resembling fish roe, cemented together.

Overburden: Overlying soil, gravel or rock that is removed in the process of mining.

Pelletizing: A method in which finely divided material is rolled in a drum or on an inclined disk, so that the particles cling together and roll up into small spherical pellets.

Permeability: The capacity of subsurface strata to transmit a fluid, expressed as the rate at which a fluid of standard viscosity (e.g., water) can move a specified distance. Permeability is dependent on the size and shape of pores in the stratum or strata, the size and shape of interconnections between pores, and the extent of these interconnections.

Phosphogypsum: See gypsum.

Pilot Scale: A demonstration or test of a process which is not full-size, but it too large to be done in a laboratory.

Pozzolanic: Able to react with lime in the presence of water at ordinary temperature to produce a cementitious compound.

Precipitation: In mineral processing, the process of separating mineral constituents from a solution by because of lowered solubility, usually caused by lowering the temperature of the solution.

Process Wastewater: Waters used or generated in one or more production operations that have accumulated contaminants to such an extent that they must be removed.

Pyrolysis: The transformation of a compound into another substance through the addition of heat.

Pyrometallurgy: Ore and mineral processing in which feedstocks are subjected to high temperatures in order to separate and remove impurities from the mineral value(s). Examples of pyrometallurgical operations include smelting and roasting.

RCRA (Resource Conservation and Recovery Act): The federal statute (P.L. 94-580, as amended) that provides EPA with the authority to regulate the treatment, accumulation, storage, disposal, and reclamation of solid and hazardous wastes.

Recycling: The return of a mineral processing residual back to the mineral processing operation that generated the material.

Refining: Mineral processing that removes impurities from an ore or mineral, beneficiated ore or mineral, or partially processed (e.g., smelted) ore or mineral.

Residuals: Materials that are generated as a consequence of processing an ore or mineral and that are not the principal product(s) of the operation. Examples include but are not limited to co- and by-products, wastes, feedstocks for further processing operations, and recycled materials. Responses to questions pertaining to specific residuals should focus on the point in the process at which the residual is generated.

Retort: A vessel used for the distillation of volatile materials, as in the separation of some metals and the destructive distillation of coal.

Reverberatory Furnace: A furnace in which heat is radiated from the roof onto the material under treatment; commonly used in the smelting of metals.

Roasting: Heating an ore or mineral or beneficiated ore or mineral with access to air, in order to effect a chemical change (e.g., expulsion of volatile material) without fusing or melting.

Secondary Material: As used in this report, a material, commonly referred to as "scrap material," which is bits and pieces of metal parts (e.g., bars, turnings, rods, sheets, or wires), which when worn or superfluous is used as feedstock in the processing of primary ores and minerals.

Sinter: To heat a mass of fine particles for a prolonged time below the melting point, usually to cause agglomeration.

Sizing: The process of separating mixed particles into groups of particles all of the same size, or into groups in which all particles range between definite maximum and minimum sizes.

Sludge: A soft mud, slush, or mire; for example, the solid product of a filtration process before drying.

Slurry Walls: An type of a containment system that prevents leachate from migrating through ground water systems. Typically, slurry walls are formed in place by excavating a trench outside the edge of a waste management unit or ground-water contaminant plume, mixing the removed native materials with a grout (e.g., bentonite clay, cement, asphalt), and immediately redepositing the slurried mixture in the trench.

Smelter Slag: The nonmetallic top layer consisting primarily of silicates and aluminosilicates of lime or other bases, which separates from the metallic products in the smelting of ores.

Smelting: The chemical reduction of a metal from its ore by a process that usually involves fusion, so that the impurities in the material, separating as lighter and more fusible slags, can be readily removed from the reduced metal, or other thermal processing wherein chemical reactions take place to produce liquid metal from a beneficiated ore.

Solvent Extraction: A method of separating one or more substances from a mixture, by treating a solution of the mixture with a solvent that will dissolve the required substances, leaving the others.

Sorting: The process of selecting one or more portions of some material on the basis of a particular characteristic (e.g., size or density).

Source Reduction: The diminution or elimination of solid and/or hazardous waste at the point of generation, usually within a process.

Speiss: Metallic arsenides and antimonides smelted from cobalt and lead ores.

Tailing(s): The residual arising from the washing, concentration, and/or treatment of ground ores or minerals (beneficiation).

Tailings Pond: A residuals management unit used for disposing tailings. Tailings ponds are typically bounded by a raised earthen embankment.

Titaniferrous: Carrying titanium, as titaniferrous iron ore (see ilmenite).

Treatment: An operation that induces a physical or chemical change in a mineral processing residual.

Vulnerable: A physical setting which facilitates the release and transport of contaminants (e.g., karst terrain), and/or a setting which is especially sensitive to contaminants.

Washing: The process of cleaning, carrying away, or eroding by the buoyant action of flowing water.

Waste Management Unit: Any location at which residuals are treated, stored, accumulated, recovered for reuse, or disposed.

Waste Pile: As used in this report, an above ground accumulation of material which may be temporary or permanent.

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Appendix A

History of the Mining Waste Exclusion for Mineral Processing Wastes

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1. Introduction

Since the proposal of the first regulations under the Resource Conservation and Recovery Act (RCRA) in 1978, mineral processing wastes have been subject to a different regulatory framework than most other categories of potentially hazardous wastes. In the 1978 proposed rule implementing Subtitle C of RCRA, EPA introduced the "special waste" concept, which was based on the belief that these "special wastes" should, on a provisional basis, be regulated less stringently than other wastes because they were produced in very large volumes, were thought to pose less of a hazard than other wastes, and were generally not amenable to the management practices required by the technical standards being proposed for other hazardous wastes.

In 1980, Congress made this "special waste" concept a statutory requirement when it enacted the Bevill Amendment as part of the 1980 amendments to RCRA. The Bevill Amendment temporarily exempted fossil fuel combustion wastes, oil and gas field production wastes, mining and mineral processing wastes, and cement kiln dust waste from potential regulation as hazardous wastes under Subtitle C of RCRA.

This Appendix provides a summary of the history of the Federal Mining Waste Exclusion, from the initial enactment of RCRA through the present.

2. The Resource Conservation and Recovery Act and Proposed Subtitle C Regulations (1976 - 1980)

On October 21, 1976, Congress enacted the Resource Conservation and Recovery Act (Pub. L. 94-580). Section 3001 of RCRA mandated that the EPA Administrator "promulgate regulations identifying characteristics of hazardous waste, and listing particular hazardous wastes which shall be subject to the provisions of this subtitle." Section 3004 required the Administrator to promulgate standards applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities. Congress did not explicitly address the regulation of mining and mineral processing wastes, but Section 8002(f) instructed the EPA Administrator to conduct:

> ..a detailed and comprehensive study on the adverse effects of solid wastes from active and abandoned surface and underground mines on the environment, including, but not limited to, the effects of such wastes on humans, water, air, health, welfare, and natural resources..."

This study requirement was based upon the Congressional recognition that mining wastes were generated in larger quantities than any other type of solid waste, and that historical and, perhaps, contemporary mining wastes management practices, could pose danger to human health and the environment. Mandated study factors included sources and volumes of wastes generated, present and alternative disposal practices, potential danger posed by surface runoff and fugitive dust emissions, the cost of waste management alternatives, and the potential for use of discarded materials as secondary sources having mineral value. The House report (No. 94-1491) accompanying the RCRA bill indicates that the focus of EPA's inquiry was to be the environmental and technical adequacy of current waste management practices, with economic practicality being a secondary consideration.

On December 18, 1978, EPA proposed its regulations for managing hazardous wastes under Subtitle C of RCRA (43 FR 58946). These proposed regulations introduced the "special wastes" concept. "Special waste" referred to wastes that were generated in large volumes, were thought to pose less risk to human health and the environment than other hazardous wastes, and for which the proposed technical requirements implementing Subtitle C might not be appropriate. EPA identified mining wastes as one of six such "special wastes" under the proposed regulations.[1] EPA proposed to defer most of the RCRA Subtitle C requirements for these special wastes until information could be gathered and assessed that would enable EPA to regulate them with special standards.

In the fall of 1979, EPA completed a draft background document that outlined the development of EPA's methodology for determining which materials qualified as "special wastes" (Introduction and Criteria for Special Waste, November 2, 1979, EPA Docket # A-D1-SS0062). The background document presents the eight criteria that were used to develop the original list of "special wastes" for the December 18, 1978 proposed Subtitle C regulations:

1. Limited information on waste characteristics;
2. Limited information on the degree of human health and environmental hazard posed by disposal;
3. Limited information on waste disposal practices and alternatives;
4. Very large volumes and/or large number of facilities;
5. Limited movement of wastes from the point of generation;
6. Few, if any, documented damage cases;
7. Apparent technological difficulty in applying current Subpart D[2] regulations to the waste because of volumes involved at typical facilities; and
8. Potential high economic impact if current Subpart D regulations are imposed.

The background document states further that criteria 1, 2, 3, 4, and 7 were the driving forces in the decision-making process for the 1978 proposed Subtitle C regulations, while the other criteria were met to some degree for individual wastes.

EPA received many public comments on the proposed Subtitle C regulations. The background document indicates that the Agency incorporated many of these comments, as well as its own continuing analysis, when it revised the criteria used to designate "special wastes." The concluding section discussed the four criteria that EPA, at that point, intended to use to evaluate petitions to designate a waste as a "special waste:"

1. The waste is or is anticipated to be generated and disposed in large volumes. This determination would be based on the national volume generated per year; the projected volume of waste generated over the next decade; the volume of waste disposed at a typical disposal facility; and extraneous siting restrictions on the generator.
2. The waste should be uniform, i.e., the waste exhibits the same characteristics whenever disposed, and is amenable to being predominantly managed without being mixed with other wastes.

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[1] The other five "special wastes" were cement kiln dust waste; utility waste; phosphate rock mining, beneficiation, and processing waste; uranium mining waste; and gas and oil drilling muds and oil production brines.

[2] 40 CFR Part 250, Subpart D contained the proposed RCRA Section 3004 management standards (43 FR 59008). These requirements are now found in final form at 40 CFR Parts 264-266).

3. The waste must pose only a low potential hazard to human health and the environment. This determination would be based on the class of hazard of the waste; the chemical composition and physical characteristics of the waste; results of the application of 40 CFR 250 Subpart A [now 40 CFR Part 261] procedures for determining hazardous characteristics and other available testing information (although ignitable, corrosive, or reactive wastes would be acceptable as special wastes at the discretion of the Administrator); and information on documented past damage cases.
4. Due to lack of information on current treatment, storage, and disposal practices and alternatives, the Agency would be unable to propose standards for control of the waste.[3]

Using the revised list of four criteria, the Agency considered expanding the list of six "special wastes" in the 1978 proposed Subtitle C regulations to a total of eleven:

1. Cement kiln dust waste;
2. Utility waste;
3. Phosphate mining, beneficiation, and processing waste;
4. Uranium mining waste;
5. Wastes from the extraction, beneficiation, and processing of ores and minerals other than phosphate rock and uranium ore;
6. Gas, oil, and geothermal drilling and production wastes;
7. Shale oil industry wastes;
8. Red muds [from bauxite refining];
9. Black muds [from bauxite refining];
10. Coal mining waste; and
11. Dredge spoils.

Though the special waste category was never promulgated, it is clear that EPA was responsible for amplifying the original study requirement under RCRA 8002(f) into a regulatory concept, that the Agency had several specific criteria (principally low hazard, high volume, and infeasibility of Subtitle C technical requirements) that it employed to evaluate potential special wastes, and that the group of wastes that might have received the temporary exemption from full Subtitle C regulation was to be both finite and relatively small.

3. Final Subtitle C Regulations and the Solid Waste Disposal Act Amendments of 1980, including the Bevill Amendment (1980)

Throughout 1980, Congress was conducting hearings to substantially amend RCRA. On February 20, 1980, Rep. Thomas Bevill (AL) offered an amendment which, among other things, amended section 3001 to temporarily exempt three categories of waste from Subtitle C regulation:

1. Fly ash waste, bottom ash waste, slag waste, and flue gas emission control waste generated primarily from the combustion of coal or other fossil fuels;
2. Solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and uranium ore; and
3. Cement kiln dust waste.

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[3] EPA also considered and rejected a number of criteria not included in the original list, including: adequacy of current waste management practices, and resource recovery potential.

These wastes were to remain exempt from Subtitle C regulation until completion of the studies required under Sections 8002(f) and 8002(n)(p), the latter of which was to be added to RCRA (these sections are discussed below).

From his statements before the Committee on Interstate and Foreign Commerce, it is apparent that Rep. Bevill offered his amendment primarily to prevent regulatory disincentives for the development of the nation's coal resources. Rep. Bevill stated that "the House [would] not allow EPA to take steps that will discourage the use of coal." Rep. Bevill noted that EPA "has very little information on the composition, characteristics, and degree of hazard posed by these [i.e., coal] wastes" and that the Agency believed that any potential hazards presented by the materials are relatively low.

Rep. Bevill also claimed that existing Federal and State regulation would sufficiently regulate wastes from the combustion of coal and other fossil fuels while EPA was undertaking the required studies. During the hearing, several other representatives spoke in favor of the Bevill Amendment, specifically concerning refuse-derived fuel (Rep. Horton-NY), fly ash and slag from coal (Rep. Findley-IL), oil and gas muds and brines (Rep. Moffett-CT), and large volume coal wastes (Rep. Rahall-WV; Rep. Staggers-WV). Rep. Florio (NJ) submitted for the record results of EPA studies that documented the known health risks associated with radioactive uranium and phosphate wastes.

The discussion of mining wastes as a part of the Bevill Amendment was limited to brief comments by Rep. Williams (MT), who stated that wastes from mineral production should not be subject to Subtitle C regulation at that time. As an example of the limited potential hazard of these wastes, Rep. Williams paraphrased a National Academy of Sciences study, stating that slag waste generated by the smelting of copper

> ...is basically inert and weathers slowly. The slag produced 2,500 years ago at King Solomon's mines north of Eliat, Israel, has not changed perceptibly over time.

Rep. Williams then continued

> Should wastes such as smelting slag be subject to stringent regulations at this time? I think not-not until a thorough study is conducted by the responsible agency which clearly proves the need for additional regulation. [Emphasis added.]

Based on Rep. Bevill's comments, it is apparent that the fundamental purpose of the amendment was to limit the impact of Subtitle C regulation on the coal industry (the Senate version of this bill, however, emphasized oil and gas field production wastes), at a time when the nation and the Congress were extremely concerned about energy self-sufficiency. Although the Bevill Amendment, as read into the record during the hearing, explicitly refers to mineral processing wastes, Rep. Bevill did not mention these wastes or respond to Rep. Williams' statements.

Almost all of the major components of the Bevill Amendment were originally conceived by EPA. The Bevill Amendment made the Agency's planned activities, as expressed in the 1978 proposed Subtitle C regulations and the 1979 "Special Waste" background document, statutory requirements. In fact, with very few exceptions, all of the specific provisions of the Bevill Amendment were lifted (often verbatim) from EPA rulemakings and related documents.

Furthermore, it is clear from the legislative history that the Bevill Amendment was designed to defer regulation of those wastes which EPA had defined as special wastes. Congressman Bevill referred specifically to EPA's 1978 special waste proposal in his explanation of the amendment, noting that EPA had asserted

> it did not have data on the effectiveness of current or potential waste management technologies or the technical or economic practicability of imposing its proposed regulations. In the same [12/18/78] announcement, EPA also stated that it believed that any potential hazards presented by the materials are relatively low.

126 Cong. Rec. 3361 (1980). Other Congressmen also referred to the Bevill wastes in terms of the EPA "special waste" concept. Congressmen Santini, Staggers, and Findley all supported the amendment on the basis that it would defer regulation of "special wastes" until EPA had completed the required study. Id. at 3348, 3349, 3363, 3365. Congressman Williams of Montana, in explaining why smelting slag should be studied (see above), noted that the Bevill Amendment "would direct [EPA] to evaluate certain high volume, low toxicity wastes so as to assure a reasoned set of regulations by which to manage these wastes." Id. at 3364. Clearly, the discussions on the floor of the House imply Congressional intent to incorporate the "special waste" concept into the Bevill Amendment definitions of excluded wastes. (See also 852 F.2d at 1327).

On May 19, 1980, EPA promulgated final regulations under Subtitle C of RCRA which addressed, among other things, "solid waste from the extraction, beneficiation, and processing of ores and minerals" (45 FR 33066). In promulgating these regulations, EPA decided to withdraw rather than finalize the "special waste" category. The Agency's stated basis for this decision was twofold:

1. The thresholds for the (EP) extraction procedure toxicity and corrosivity characteristics tests (which are used to identify hazardous wastes subject to Subtitle C regulation) had been significantly relaxed. As a result, the number of wastes in general, and "special wastes" in particular, that would be potentially subject to Subtitle C regulation was greatly reduced.
2. The Agency had incorporated more flexibility, through permitting and standard-setting, in Parts 264 and 265 (which contain the regulations for permitted and interim status owners/operators of hazardous waste facilities). Thus, a RCRA permit writer had the ability to take into account site-specific environmental characteristics and management practices (i.e., "special waste" study factors) in establishing permit requirements.

As a result, the Agency concluded that these changes "accomplish the objectives of, and eliminate the need for, a special solid waste category." When EPA eliminated the "special waste" concept, it was aware of Congress' intention to exempt mining and mineral processing and other proposed "special" wastes from Subtitle C regulation because passage of the Solid Waste Disposal Act Amendments of 1980 (including the Bevill Amendment) was expected (Senate and House versions had been passed on June 4, 1979 and February 20, 1980, respectively).

On October 12, 1980, Congress enacted the Solid Waste Disposal Act Amendments of 1980 (Pub. L. 96-482), which added section 3001(b)(3)(A)(ii) (the Bevill Amendment) to RCRA. This section temporarily prohibits EPA from regulating, among other wastes, "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore" as hazardous waste under Subtitle C of RCRA until at least six months after EPA completes and submits to Congress the studies required by Section 8002(f), and by Section 8002(p), which was also added to RCRA by the 1980 amendments. Section 8002(p) required the Administrator to study the adverse effects on human health and the environment, if any, of the waste from the disposal and utilization of "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ores," and submit a Report to Congress on its findings by October, 1983. The 1980 amendments also added section 3001(b)(3)(C), which requires the Administrator to make a regulatory determination, within six months of the completion of the section 8002 studies, whether to regulate the studied wastes under Subtitle C of RCRA.

On November 19, 1980, EPA published an interim final amendment to its hazardous waste regulations to reflect this mining waste exclusion (45 FR 76618). The regulatory language incorporating the exclusion was identical to the statutory language, except EPA added the phrase "including coal." In the preamble to the amended regulation, however, EPA tentatively interpreted the exclusion to include "solid waste from the exploration, mining, milling, smelting, and refining of ores and minerals." The preamble made it clear that the Agency was interpreting the scope of the exclusions very broadly within the context of the mining industry, and that, over the next 90 days, EPA intended to review the legislative history of the Bevill Amendment and the public comments received in response to the interpretation. The preamble indicated that based on this review, EPA would probably narrow the scope of the exclusion.

4. Litigation, the Hazardous and Solid Waste Amendments of 1984, and Bevill Exclusion Reinterpretations (1981 - 1988)

As noted above, the Solid Waste Disposal Act Amendments of 1980 amended section 3001 to require the EPA Administrator to make a regulatory determination regarding the wastes temporarily excluded from Subtitle C regulation within six months of submitting the required Report to Congress. EPA was required to submit the Report to Congress by October, 1983. In 1984, the Concerned Citizens of Adamstown and the Environmental Defense Fund sued EPA for failing to complete the section 8002 studies and the regulatory determination by the statutory deadlines (*Concerned Citizens of Adamstown v. EPA*, No. 84-3041, D.D.C., August 21, 1985). EPA explained to the District Court for the District of Columbia that the Agency planned to propose to "reinterpret" the scope of the mining waste exclusion so that it would encompass fewer wastes. Therefore, EPA suggested two schedules to the court: one for completing the section 8002 studies and submitting the Report to Congress, and one for proposing and taking final action on the reinterpretation. On August 21, 1985, the court ordered EPA to meet these two schedules; first, the Agency was to complete the section 8002 studies and Report to Congress by December 31, 1985, and to publish the regulatory determination by June 30, 1986; and second, EPA was to propose to reinterpret the Bevill exclusion and subsequently, to take final action on the proposed reinterpretation by September 30, 1986.

EPA submitted the Report to Congress on December 31, 1985. The Report to Congress provided information on sources and volumes of waste, disposal and utilization practices, potential danger to human health and the environment from mining practices, and evidence of damages. EPA focused on the mining industry segments that produced and/or concentrated metallic ores, phosphate rock, or asbestos.

On July 3, 1986, EPA issued its regulatory determination for the mining wastes covered by the Report to Congress (51 FR 24496). The regulatory determination concluded that Subtitle C regulation of the wastes studied in the Report to Congress (i.e., extraction and beneficiation wastes) was not warranted at that time. This conclusion was based on EPA's belief that aspects of the Subtitle C standards were likely to be environmentally unnecessary, technically infeasible, or economically impractical when applied to mining waste. EPA announced its intention to develop a program for mining waste under Subtitle D of RCRA.

The July 3, 1986 regulatory determination was subsequently challenged in court (*Environmental Defense Fund v. EPA*, 852 F.2d 1309 (D.C. Cir. 1988)). The Court of Appeals upheld EPA's regulatory determination for extraction and beneficiation wastes.

In the interim, Congress enacted the Hazardous and Solid Waste Amendments to RCRA in 1984. These amendments added new requirements applicable to owners and operators of facilities that treat, store, or dispose hazardous waste, and included minimum technical standards for the design, construction, and operation of waste management units, land disposal restrictions, and corrective action requirements for continuing releases. In developing these new requirements, Congress considered their feasibility with respect to and potential impact on the management of certain categories of wastes. This concern was embodied in what was to become Section 3004(x) of RCRA, the so-called "Simpson Amendment," which allowed the EPA Administrator to modify the Subtitle C technical standards for managing mining wastes, utility waste, and cement kiln dust waste, as long as protection of human health and the environment was assured.

In the floor debate on the Simpson Amendment, the Senate considered remarks concerning the types of wastes that would be eligible for the special status conferred by the amendment. Sen. Jennings Randolph (WV) read into the record the description of mining wastes that was contained in the committee report on the HSWA amendments. In this report, "solid wastes from mining and mineral beneficiation and processing" are described as "primarily waste rock from the extraction process, and crushed rock, commonly called tailings..." The report continues by stating

> [t]he 1980 amendments covered wastes from the initial stages of mineral processing, where concentrations of minerals of value are greatly increased through physical means, before applying secondary processes such as pyrometallurgical or electrolytic methods. Smelter slag might also be included... These wastes were considered "special wastes" under the 1978 proposed regulations as being of large volume and relatively low hazard. [Emphasis added.]

The remaining discussion in the excerpt from the committee report focuses on the potential difficulties of managing the huge volumes of waste rock and tailings associated with mineral exploitation under the new minimum technology standards under debate.

Thus, although the Congress explicitly considered the special study wastes in crafting the provisions of HSWA, there is nothing in either the amendments themselves or in the legislative record supporting them to suggest that Congress construed the term "mineral processing" broadly, i.e., to include wastes that are not "special wastes."

In keeping with its agreement in the *Adamstown* case, on October 2, 1985, EPA proposed to narrow the scope of the Bevill exclusion (50 FR 40292). In preparing the proposed mining waste exclusion, EPA implicitly applied the "high volume, low hazard, special waste" concept from EPA's 1978 proposed hazardous waste regulations. The proposed rulemaking would have eliminated from the mining waste exclusion most wastes from the processing of ores and minerals; EPA proposed to retain bauxite refining muds, phosphogypsum from phosphoric acid plants, and slag from primary metal smelters and phosphorus reduction facilities within the Bevill exclusion. In the preamble, EPA stated that Congressional intent supported the Agency's special waste concept. The proposed rule did not, however, outline the criteria that EPA used to determine high volume or low hazard.

In response to the proposed reinterpretation, many commenters "nominated" additional wastes that they believed fit the "special waste" criteria, and therefore should also be excluded from Subtitle C regulation as "processing wastes." Because EPA had not explicitly defined the terms "high volume" or low hazard" in the October 2, 1985 proposal, the Agency was unable to determine the regulatory status of these nominated wastes. EPA could not infer definitions for these terms based upon the four wastes listed in the proposal as meeting the "special waste" criteria. The public comments on the proposal and the Agency's analysis indicated that the proposed reinterpretation could not be finalized because it did not set out "practically applicable" criteria for distinguishing "processing" (i.e., high volume, low hazard ore and mineral processing residuals) from non-processing wastes (i.e., non-excluded) wastes. Moreover, the Agency was unsure whether such criteria could be developed. Therefore, faced with the court-ordered deadline for final Agency action in *Adamstown*, EPA withdrew the proposal on October 9, 1986 (51 FR 36233). As a consequence, the interpretation of the mining waste exclusion established in the November 19, 1980 rulemaking notice remained in effect.

The Agency's decision to withdraw its proposed reinterpretation of the mining waste exclusion was subsequently challenged in court (*Environmental Defense Fund v. EPA*, 852 F.2d 1316 (D. C. Cir. 1988), cert. denied 109 S. Ct. 1120 (1989) (*EDF v. EPA*)). In this case, the petitioners contended, and the Court of Appeals agreed, that EPA's withdrawal of its proposed reinterpretation of the Bevill Amendment was arbitrary and capricious because it reaffirmed an "impermissibly over-broad interpretation" of the Bevill Amendment. *EDF v. EPA*, 852 F.2d at 1326.

In reaching this decision, the Court found that the words "waste from ... processing of ores and minerals" do not convey a self-evident, accepted meaning. Id. at 1327. Therefore, the Court reviewed the structure and the legislative history of the Bevill Amendment to ascertain the intent of Congress. The Court found that "[t]he structure of the Bevill Amendment suggests that the term 'solid waste from the . . . processing of ores and minerals' should be interpreted in a manner consistent with the concept of large volume wastes." Id. The Court also decided that "[t]he legislative history of the Bevill Amendment establishes that the key to understanding Congress's intent is the concept of 'special waste' articulated in the regulations proposed by EPA on December 18, 1978 following the enactment of RCRA." Id. See 43 FR 58911 (1978) and 50 FR 40293 (1985).

In explaining this decision, the Court cited statements made by members of Congress during the legislative consideration of the exclusion and the description of the provision in the Conference Report accompanying the legislation. Based on these indications of Congressional intent, the court concluded that

> it is clear that Congress did not intend the mining waste exclusion to encompass all wastes from primary smelting and refining. On the contrary, Congress intended the term "processing" in the Bevill Amendment to include only those wastes from processing ores or minerals that meet the "special waste" criteria, that is, "high volume, low hazard" wastes. 852 F.2d at 1328-29.

Thus, when the Agency withdrew its October 2, 1985, proposed reinterpretation of the mining waste exclusion, which was based on implicit "special waste" criteria, EPA by default reverted to its November 19, 1980, interpretation of the exclusion, which did not distinguish between high volume, low hazard processing wastes and other processing wastes. As a consequence, the number of temporarily excluded processing wastes remained very large. The Court ruled that this result was inconsistent with Congressional intent. Therefore, the Court ordered EPA to propose, by October 15, 1988, a specific list of mineral processing wastes that meet the criteria of high volume and low hazard, and thus remain temporarily excluded from Subtitle C regulation. 852 F.2d at 1331.

5. Final Reinterpretation of the Mining Waste Exclusion (1988-1990)

In compliance with this Court decision, on October 20, 1988 EPA published a proposal to further define the scope of Section 3001(b)(3)(A)(ii) of RCRA. (See 53 FR 41288.) In the October 20, 1988 proposal, EPA presented a criterion for defining mineral processing wastes and a two-part criterion for identifying which mineral processing wastes are high volume; however, the Agency proposed to defer judgment on the hazard posed by high volume mineral processing wastes until preparation of a required Report to Congress. The Agency also applied the processing and volume criteria to its available data on mineral processing wastes, and identified 15 wastes which it believed met the criteria, and which the Agency therefore proposed to retain within the exclusion and study for the Report to Congress:

1. Slag from primary copper smelting
2. Process wastewater from primary copper smelting/refining
3. Blowdown from acid plants at primary copper smelters
4. Bleed electrolyte from primary copper refining
5. Slag from primary lead smelting
6. Blowdown from acid plants at primary zinc smelters
7. Process wastewater from primary zinc smelting/refining
8. Red and brown muds from bauxite refining
9. Phosphogypsum from phosphoric acid production
10. Slag from elemental phosphorus production

11. Iron blast furnace slag
12. Air pollution control dust/sludge from iron blast furnaces
13. Waste acids from titanium dioxide production
14. Air pollution control dust from lime kilns
15. Slag from roasting/leaching of chromite ore.

Based on comments received on the October 20, 1988 NPRM and further analysis, EPA decided that significant changes in the proposal were necessary before a final rule establishing the boundaries of the Bevill exclusion for mineral processing wastes could be promulgated. Accordingly, on April 17, 1989, the Agency published a revised proposed rule that contained a modified high volume criterion, clarifications to the definition of mineral processing, and for the first time, an explicit low hazard criterion. As stated in the April notice, EPA believed that such a criterion is required in order to identify those mineral processing wastes that are clearly not low hazard and, therefore, not "special wastes" even if they are high volume.

In the April NPRM, the Agency also proposed to remove from the Bevill exclusion all but 39 mineral processing wastes, many of which were "nominated" in public comment on the October NPRM. Of these 39, six wastes were believed at that time to satisfy all of the "special waste" criteria described in the proposal:

1. Slag from primary copper smelting
2. Slag from primary lead smelting
3. Red and brown muds from bauxite refining
4. Phosphogypsum from phosphoric acid production
5. Slag from elemental phosphorus production
6. Furnace scrubber blowdown from elemental phosphorus production.

The other 33 wastes were proposed to be conditionally retained within the exclusion, because they are mineral processing wastes that the Agency believed satisfied the volume criterion articulated in the proposal but for which the Agency did not have adequate data to evaluate compliance with the proposal's new hazard criterion. Thus, the following 33 wastes were judged, based in many cases upon information submitted in public comment, to have generation rates that might exceed 50,000 metric tons per year per facility, and therefore, be potentially eligible for continued exclusion under Bevill:

1. Barren filtrate from primary beryllium processing
2. Raffinate from primary beryllium processing
3. Bertrandite thickener sludge from primary beryllium processing
4. Process wastewater from primary cerium processing
5. Ammonium nitrate process solution from primary lanthanide processing
6. Roast/leach ore residue from primary chrome ore processing
7. Gasifier ash from coal gasification
8. Cooling tower blowdown from coal gasification
9. Process wastewater from coal gasification
10. Bleed electrolyte from primary copper refining
11. Process wastewater from primary copper smelting/refining
12. Slag tailings from primary copper smelting
13. Calcium sulfate wastewater treatment plant sludge from primary copper smelting/refining
14. Furnace off-gas solids from elemental phosphorus production

15. Process wastewater from elemental phosphorus production
16. Fluorogypsum from hydrofluoric acid production
17. Air pollution control dust/sludge from iron blast furnaces
18. Iron blast furnace slag
19. Process wastewater from primary lead smelting/refining
20. Air pollution control scrubber wastewater from lightweight aggregate production
21. Wastewater treatment sludge/solids from lightweight aggregate production
22. Process wastewater from primary magnesium processing by the anhydrous process
23. Process wastewater from primary selenium processing
24. Process wastewater from phosphoric acid production
25. Wastes from trona ore processing
26. Basic oxygen furnace slag from carbon steel production
27. Leach liquor from primary titanium processing
28. Sulfate processing waste acids from titanium dioxide production
29. Sulfate processing waste solids from titanium dioxide production
30. Chloride processing waste acids from titanium and titanium dioxide production
31. Chloride processing waste solids from titanium and titanium dioxide production
32. Blowdown from acid plants at primary zinc smelters
33. Process wastewater from primary zinc smelting/refining.

All other waste streams from mineral processing were proposed to be removed from the exclusion. Most of the remaining streams were low volume; three high volume wastes were proposed for removal on the basis of hazard: acid plant/scrubber blowdown from the primary copper, lead, and tin sectors.

On September 1, 1989 (see 54 FR 36592), EPA provided the final Bevill exclusion criteria. The September 1 rulemaking also finalized the Bevill status of five mineral processing waste streams. EPA temporarily retained these wastes within the Bevill exclusion for study in the July 1990 Report to Congress:

1. Slag from primary copper processing
2. Slag from primary lead processing
3. Red and brown muds from bauxite processing
4. Phosphogypsum from phosphoric acid production
5. Slag from elemental phosphorus production.

In addition, the Agency modified the list of mineral processing wastes proposed for conditional retention in April 1989. In the September 1 rulemaking, the Agency conditionally retained 20 mineral processing wastes within the Bevill exclusion:

1. Roast/leach ore residue from primary chromite production
2. Gasifier ash from coal gasification
3. Process wastewater from coal gasification
4. Calcium sulfate wastewater treatment plant sludge from primary copper processing
5. Slag tailings from primary copper processing
6. Furnace off-gas solids from elemental phosphorus production

7. Fluorogypsum from hydrofluoric acid production
8. Process wastewater from hydrofluoric acid production
9. Air pollution control dust/sludge from iron blast furnaces
10. Iron blast furnace slag
11. Process wastewater from primary lead production
12. Air pollution control dust/sludge from lightweight aggregate production
13. Process wastewater from primary magnesium processing by the anhydrous process
14. Process wastewater from phosphoric acid production
15. Basic oxygen furnace and open hearth furnace air pollution control dust/sludge from carbon steel production
16. Basic oxygen furnace and open hearth furnace slag from carbon steel production
17. Sulfate process waste acids from titanium dioxide production
18. Sulfate process waste solids from titanium dioxide production
19. Chloride process waste solids from titanium tetrachloride production
20. Slag from primary zinc processing.

All other mineral processing wastes that were not conditionally retained were permanently removed from the Bevill exclusion as of the effective date of the September 1, 1989 rule (March 1, 1990 in non-authorized states), subjecting these wastes to RCRA Subtitle C regulation if they are solid wastes and exhibit one or more of the characteristics of hazardous waste as defined in 40 CFR Part 261.

On September 25, 1989 (54 FR 39298), EPA reevaluated the status of the 20 conditionally retained wastes. Applying the high volume and low hazard criteria contained in the September 1, 1989 final rule, the Agency proposed to permanently remove seven mineral processing wastes from the Bevill exclusion and retain 13 other mineral processing wastes within the exclusion for study in the Report to Congress.

On January 23, 1990, a final rule established the status of the 20 mineral processing wastes which were proposed either for removal from or retention in the Bevill exclusion in the September 25, 1989 notice of proposed rulemaking (NPRM); fifteen of these wastes were retained in and five wastes were removed from the exclusion by this notice. In addition, the rule contained technical corrections to the September 1, 1989 final rule. Furthermore, the January final rule promulgated a clarification to the definition of "designated facility" that the Agency proposed on September 25, 1989.

The January final rule completed EPA's rulemaking process regarding the RCRA status of mineral processing wastes until the completion of the required Report to Congress and Regulatory Determination. In establishing the final Bevill status for these 20 mineral processing wastes, the Agency considered information presented in public comment on the September 25 proposal together with additional analysis of previously collected EPA industry survey and field data and, where appropriate, modified the decisions made in the September 25 proposal.

As in the September 25 proposal, the Agency evaluated the 20 mineral processing wastes by applying the high volume and low hazard criteria contained in the September 1, 1989 final rule, using a three-step process. First, the Agency applied the high volume criterion to the available waste generation data. For each waste, the Agency obtained facility-specific annual waste generation rates for the period 1983-1988 and used the highest average annual facility-level generation rate in calculating the sector-wide average. Mineral processing wastes generated above the volume criterion thresholds (an average rate of 45,000 metric tons per facility for non-liquid wastes, and 1,000,000 metric tons for liquid wastes) passed the high volume criterion.

In the second step, the Agency evaluated each of the 20 wastes with respect to the low hazard criterion using the relevant waste characteristics. EPA considered a waste to pose a low hazard only if the waste passed both a toxicity test (Method 1312) and a pH test.

The third step involved consolidating the results from the first two steps to determine the appropriate Bevill status of the 20 conditionally retained mineral processing wastes. Applying these criteria, the Agency removed the Bevill exclusion for the following five mineral processing wastes:

1. Furnace off-gas solids from elemental phosphorus production
2. Process wastewater from primary lead processing
3. Air pollution control dust/sludge from lightweight aggregate production
4. Sulfate process waste acids from titanium dioxide production
5. Sulfate process waste solids from titanium dioxide production.

The following 15 mineral processing wastes were retained within the exclusion (in addition to the five already retained in the September 1 rule), pending preparation of this Report to Congress and the subsequent Regulatory Determination:

1. Treated residue from roasting/leaching of chrome ore
2. Gasifier ash from coal gasification
3. Process wastewater from coal gasification
4. Calcium sulfate wastewater treatment plant sludge from primary copper processing
5. Slag tailings from primary copper processing
6. Fluorogypsum from hydrofluoric acid production
7. Process wastewater from hydrofluoric acid production
8. Air pollution control dust/sludge from iron blast furnaces
9. Iron blast furnace slag
10. Process wastewater from primary magnesium production by the anhydrous process
11. Process wastewater from phosphoric acid production
12. Basic oxygen furnace and open hearth furnace air pollution control dust/sludge from carbon steel production
13. Basic oxygen furnace and open hearth furnace slag from carbon steel production
14. Chloride process waste solids from titanium tetrachloride production
15. Slag from primary zinc processing.

The January rule also contained technical corrections to the September 1, 1989 final rule. The Agency's review of the final rule, as well as public comments, revealed slight differences between portions of the regulatory language and the corresponding discussion in the preamble. As a result, the January rule included minor editorial changes to the language of the September 1 final rule.

The January rule established the boundaries of the temporary exclusion from hazardous waste regulations for mineral processing wastes provided by RCRA Section 3001(b)(3)(A)(ii). All 20 mineral processing wastes for which the Bevill exclusion has been retained have been subject to detailed study in this Report to Congress.

Appendix B

EPA Data Collection Activities

Appendix B-1

Description of the 1989 National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF Survey)

Appendix B-1
Description of the 1989 National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF Survey)

In order to be fully responsive to the individual study factors provided in Section 8002(p) of RCRA, EPA needed to obtain information that specifically pertained to the facilities, processes, and management practices that are associated with the ore and mineral processing wastes that are covered by the Mining Waste Exclusion. Accordingly, in February of 1989, EPA administered a written questionnaire to the operators of all facilities that, to the Agency's knowledge, generated one or more of the ore and mineral processing waste streams that the Agency was, at that time, considering retaining within the Exclusion. The survey consisted of approximately 300 questions, and was distributed to the operators of about 200 mineral processing facilities.

EPA requested that a person who was knowledgeable about the waste management practices utilized at the particular facility provide written answers to the questions in the survey, and submit these responses to the Agency. EPA then analyzed these data, and has used them to respond to the requirements of RCRA Section 8002(p) in preparing this report. In particular, the data collected allowed the Agency to address the sources and volumes of the excluded wastes (study factor 1), current and alternative waste management practices (study factors 2 and 5), costs of alternative waste management practices (study factor 6), and potential danger to human health and the environment (study factor 3).

Data necessary to evaluate documented cases of danger (study factor 4), current and potential utilization of ore and mineral products (study factor 8), and potential impacts of waste management alternatives on the use of mineral resources (study factor 7) were developed through other sources (primarily intensive literature reviews, state contacts, and the U.S. Bureau of Mines).

The questionnaire was divided into nine sections. A description of each section, the types of information that it was designed to elicit, and the uses of the information obtained thereby is presented below:

- Section 1 - General facility information. This section requested information on the owner, operator, location, and operating status of the facility. In addition, this section contained questions that addressed the proximity of the facility to sensitive environments. Responses to these questions allowed EPA to verify important background data, and enabled the Agency to perform screening-level analyses of potential risk to human health and the environment, as well as to collect financial data needed for economic impact assessment.
- Section 2 - Processing units that generate a special waste. The questions in this section pertained to the specific points in the production process at which the special wastes were and are generated. The emphasis of the section was on gaining knowledge of how, where, and why these materials are generated. Respondents were asked to describe all on-site processes that generate each waste of concern. One duplicate set of questions was provided in an appendix to the questionnaire.
- Section 3 - Processing units that receive a special waste (or its residue). This section sought information on on-site operating units that utilized one or more special wastes as feedstocks, and produced final or intermediate products (i.e., materials of value). This information was also used to characterize current and alternative waste management practices. In particular, this section enabled EPA to evaluate the extent to which some of the special wastes are indeed handled as in-process feedstocks rather than wastes, as a number of facility operators and industry trade associations have claimed.

- Section 4 - Wastewater treatment plants that receive a special waste (or its residue). The questions in this section pertained to the specific practices that were employed in on-site wastewater treatment plants to manage special wastes. (These operations are sufficiently different than other types of waste management units to justify addressing them separately.) Questions pertained to capacity, treatment technologies employed, residues generated, and the fate of each of these treatment residues. This information was utilized to evaluate current, and especially, alternative waste management practices.

- Section 5 - Surface impoundments that receive a special waste (or its residue). The content and format of this section mirrored that of section 4, except that the questions were specifically oriented toward the characteristics of surface impoundments, a major waste management technology employed in the mineral processing industry. Once again, the nature of surface impoundments differs significantly from other waste management unit types; hence, for clarity, these units were addressed in their own section.

- Section 6 - Other waste management units that receive a special waste (or its residue). This section contained a series of questions that pertained to all other specific management practices that are applied to the special wastes and their treatment residues. This information is vital to EPA's understanding of the extent to which current industry practice is adequate to prevent releases of contaminants to the environment. In addition, EPA estimated the costs of these contemporary management practices to provide a baseline against which the costs of regulatory alternatives are compared. Again, an additional copy of some questions was provided in an appendix, so that the respondents could clearly and unambiguously describe all waste management units that handle a special waste and its residues.

- Section 7 - Environmental monitoring near waste management units. This section contained questions that addressed important environmental variables and any environmental monitoring that facility operators are conducting. Responses were used to assess actual and potential environmental contamination arising from the current practices used to manage special wastes.

- Section 8 - Waste management units not covered in sections 5 and 6. The questions in this section were in some instances similar in content to those in sections 5 and 6, but focused on any additional waste management units that do not receive or generate any special wastes or residues of special wastes. This information is required to assess the likelihood that documented or potential environmental contamination episodes are due to the improper management of wastes that are outside of the scope of the Report to Congress and to assess the potential need to conduct corrective action.

- Section 9 - Follow-up information. This final section simply requested the name, title, address, and telephone number of a person whom EPA could contact if clarification of the information provided to the Agency by the respondent was required.

Appendix B-2

Description of 1989 EPA Sampling and Analysis Activities

Appendix B-2
Description of 1989 EPA Sampling and Analysis Activities

This appendix provides a summary of the EPA mineral processing waste sampling and analysis activities conducted during 1989 in support of rulemaking activities and preparation of this report. It includes brief descriptions of the background, objectives, and scope of the sampling effort, the methodology used to select candidate facilities, and the facilities that EPA sampled. The results of the sampling effort as they relate to the wastes covered by this report are presented in the supporting public docket (F-90-RMPA-FFFFF).

Background

Section 8002(p) of the Resource Conservation and Recovery Act (RCRA) requires EPA to study the adverse effects on human health and the environment, if any, from the disposal and utilization of "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore," and submit a Report to Congress on its findings. Section 3001 of RCRA excludes these wastes from regulation under Subtitle C of RCRA, pending completion of the study called for in section 8002(p). These provisions are collectively often referred to as "the Mining Waste Exclusion." Since 1980, EPA has interpreted the language of Section 8002(p) to include "solid waste from the exploration, mining, milling, smelting, and refining of ores and minerals" (45 FR 76618).

In response to the decision of the Court of Appeals in Environmental Defense Fund v. EPA, 852 F.2d 1316, D. C. Cir., 1988 (EDF v. EPA), EPA proposed (53 FR 41288, October 20, 1988) to narrow the scope of the Mining Waste Exclusion such that only 15 specific mineral processing wastes would be addressed in the study required by RCRA §8002(p); other mineral processing wastes were proposed to become subject to RCRA Subtitle C regulations if they exhibit one or more characteristics of hazardous waste. The 15 wastes proposed for study were distinguished from other mineral processing wastes based on the fact that they are generated in large volumes.

Based on public comments on the proposal and additional analysis, EPA subsequently proposed that mineral processing wastes to be studied be "low hazard" as well as "large volume." (See 54 FR 15316, April 17, 1989.) In the April proposal, EPA proposed to include six wastes within the scope of the §8002(p) study and indicated that the Agency needed more data to determine whether 33 additional wastes that met the proposed "high volume" criterion were also "low hazard" and, thus, would also be included in the study.

Objectives

The primary objective of collecting and analyzing mineral processing waste samples was to obtain the knowledge of the physical and chemical characteristics of the wastes that was needed to aid in determining which large volume wastes are "low hazard." The secondary objective was to provide information for use in evaluating the Section 8002(p) study factors for the required Report to Congress.

Scope

The types of wastes covered by the sampling and analysis effort were determined based on the Agency's April 17, 1989 proposal noted above. Specifically, the types of wastes covered by the sampling effort included: (1) the 33 types of waste proposed for conditional exclusion from RCRA Subtitle C requirements pending collection of information needed to determine if they are "low hazard"; (2) the three large volume wastes that the Agency proposed to remove from the exclusion because they were believed not to be "low hazard"; and (3) additional large volume wastes identified in public comments on the proposed rule. The 33 wastes proposed for conditional exclusion on April 17, 1989 were as follows:

- barren filtrate from primary beryllium processing;
- raffinate from primary beryllium processing;
- bertrandite thickener sludge from primary beryllium processing;
- process wastewater from primary cerium processing;
- ammonium nitrate process solution from primary lanthanide processing;
- roast/leach ore residue from primary chrome ore processing;
- gasifier ash from coal gasification;
- cooling tower blowdown from coal gasification;
- process wastewater from coal gasification;
- bleed electrolyte from primary copper refining;
- process wastewater from primary copper smelting/refining;
- slag tailings from primary copper smelting;
- calcium sulfate wastewater treatment plant sludge from primary copper smelting/refining;
- furnace off-gas solids from elemental phosphorus production;
- process wastewater from elemental phosphorus production;
- fluorogypsum from hydrofluoric acid production;
- air pollution control dust/sludge from iron blast furnaces;
- iron blast furnace slag;
- process wastewater from primary lead smelting/refining;
- air pollution control scrubber wastewater from lightweight aggregate production;
- wastewater treatment sludge/solids from lightweight aggregate production;
- process wastewater from primary magnesium processing by the anhydrous process;
- process wastewater from primary selenium processing;
- process wastewater from phosphoric acid production;
- wastes from trona ore processing;
- basic oxygen furnace slag from carbon steel production;
- leach liquor from primary titanium processing;
- sulfate processing waste acids from titanium dioxide production;
- sulfate processing waste solids from titanium dioxide production;
- chloride processing waste acids from titanium and titanium dioxide production;
- chloride processing waste solids from titanium and titanium dioxide production;
- blowdown from acid plants at primary zinc smelters; and
- process wastewater from primary zinc smelting/refining.

The 3 large volume wastes that EPA proposed to remove from the mining waste exclusion because they are not "low hazard" were:

- acid plant and scrubber blowdown from primary copper processing;
- acid plant blowdown from primary lead processing; and
- air pollution control scrubber blowdown from primary tin processing.

Additional large volume wastes identified in comments on the proposed rule and included in the sampling effort were:

- basic oxygen furnace and open hearth furnace air pollution control dust/sludge from carbon steel production;
- open hearth furnace slag from carbon steel production;
- process wastewater from hydrofluoric acid production, and
- sulfate leach residue from primary copper processing.

Samples of each of these 38 types of waste[1] were collected at the point of waste generation from at least two facilities (except for waste types that are only generated by a single facility) because this was the minimum amount of data needed to implement the proposed "low hazard" criterion. In addition, EPA sampled the following five wastes, for which the Agency proposed on April 17, 1989 to retain the exclusion, where these wastes were generated at facilities that were visited for sampling of the 38 wastes listed above:

- slag from primary copper smelting;
- slag from primary lead smelting;
- phosphogypsum from phosphoric acid production;
- slag from elemental phosphorus production; and
- furnace scrubber blowdown from elemental phosphorus production.

One additional waste for which the Agency proposed to retain the mining waste exclusion, red and brown muds from bauxite refining, was not sampled because sampling visits to the facilities that generate this waste were not otherwise required.

In general, the wastes were also sampled "as managed" (e.g., after treatment or disposal) to provide information that could be used in the assessment of potential danger to human health and the environment for the Report to Congress.

Selection of Facilities for Sampling

Based on information provided by the U.S. Bureau of Mines, state agencies, and public comments received on the October 20, 1988 and April 17, 1989 proposed rules, EPA developed a list of the facilities in the United States that were thought to generate one or more of the 38 large volume mineral processing wastes identified for sampling. This list of facilities defined the universe of facilities from which individual facilities were selected for sampling.

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[1] No primary tin processing facilities were in operation at the time the sampling was conducted, so air pollution control scrubber blowdown from primary tin processing was not sampled. In addition, basic oxygen furnace slag and open hearth furnace slag from carbon steel production were subsequently combined and considered to be a single waste type, though both were sampled separately. As a result, the number of mineral processing wastes discussed here as identified for sampling is 38 rather than 40.

EPA selected facilities for sampling from this list using the following procedure:

Step 1. Select facilities for sampling that generate any of the 38 wastes that are generated by only one or two facilities. This step resulted in the selection of 15 facilities in eight commodity sectors[2] that generate 18 types of waste that are generated by two or fewer facilities. Three of the 15 selected facilities (in the copper sector) also provide for collection of at least two samples of each of three additional waste types.[3] Thus, this step provides for sampling of 21 of the 38 wastes.

Step 2. Select facilities randomly from the ten commodity sectors[4] that have three or more facilities that generate one or more of the other 17 wastes, such that each of the 17 wastes can be sampled at two or more facilities. For each commodity sector, EPA generated three random numbers (between 0 and 1) using a Lotus 1-2-3 random number generator and multiplied each of the three numbers by the number of facilities in the commodity sector. The product of the first random number and the number of facilities in the sector, rounded off to the next highest whole number, was the number of the first facility chosen for sampling.[5] The second number was the number of the second facility chosen for sampling. If the first two facilities selected both generated all of the wastes generated by the sector that needed to be sampled (exclusive of wastes covered in step 1 above), then selection of facilities for sampling in the sector was complete. If not, then a third (or additional) facility was selected in the same way until each waste could be sampled at at least two facilities. This step resulted in the selection of 22 facilities for sampling.

Following completion of this site selection procedure, data from the "National Survey of Wastes from Mineral Processing Facilities" became available that indicated that several facilities on the initial list of facilities selected for sampling did not generate one or more of the wastes that EPA planned to sample at the facility. In these cases, the next random number for the sector was used to select an alternate facility for sampling. Similarly, telephone calls to selected facilities that EPA made to collect information needed to plan the sampling visits sometimes led to the conclusion that a facility needed to be deleted from the sampling frame. In these cases, the next random number for the sector also was used to select an alternate facility for sampling.

Facilities Selected for Sampling

The 37 facilities that were selected for sampling based on the procedures described above are listed in Exhibit B-2-1. Of these 37 facilities, only 27 facilities generate one or more wastes that are covered by this report. These 27 facilities are identified with asterisks in Exhibit B-2-1.

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[2] Beryllium, cerium/lanthanide, chrome ore, coal gasification, copper, magnesium, molybdenum, and titanium.

[3] It is also the case that the two facilities selected for sampling of sulfate process wastes from titanium ore processing generate the chloride process wastes that also needed to be sampled. However, these facilities do not use the predominant chloride process or feedstocks, so additional facilities were selected for sampling.

[4] Elemental phosphorus, hydrofluoric acid, iron/steel, lead, copper, lightweight aggregate, phosphoric acid, soda ash, titanium, and zinc.

[5] For example, if 0.4467 is the first random number generated and there are 4 facilities in the commodity sector, the second facility was the first facility selected for sampling [0.4467 x 4 = 1.7868, rounded up to the nearest whole number is 2].

Exhibit B-2-1
Mineral Processing Facilities Sampled By EPA For The Report To Congress

Commodity Sector	Facility
Beryllium	Brush Wellman Co., Delta, UT
Cerium/Lanthanides	Molycorp, Inc., Louviers, CO Molycorp, Inc., York, PA
Sodium Dichromate	Occidental Chemical Corp., Castle Hayne, NC* American Chrome and Chemical, Corpus Christi, TX*
Coal Gasification	Dakota Gasification, Beulah, ND*
Copper	ASARCO Inc., Hayden, AZ* Kennecott Utah Copper, Bingham Canyon, UT* Magma Copper Co., San Manuel, AZ* Cypress, Casa Grande, Casa Grande, AZ
Elemental Phosphorus	FMC Corp, Pocatello, ID* Stauffer Chemical, Mt. Pleasant, TN*
Hydrofluoric Acid	Allied-Signal Corp, Geismar, LA* Pennwalt Corp., Calvert City, KY*
Iron/Steel	Sharon Steel Corp., Sharon, PA* USX, Lorain, OH* USA, Fairless, PA* USX, Braddock, PA* Bethlehem Steel, Sp[illegible]ws Point, MD*
Lead	ASARCO, East Helen[illegible] MT* ASARCO, Glover, MO Doe Run Company, Herculaneum, MO*
Lightweight Aggregate	Northeast Solite Corp., Mount Marion, NY Arkansas Lightweight Aggregate, W. Memphis, AR
Magnesium	Magnesium Corp. of America, Salt Lake City, UT*
Molybdenum	Climax Molybdenum, Fort Madison, IA
Phosphoric Acid	IMC, Mulberry, FL* CF Industries, Plant City, FL*
Soda Ash	Stauffer Chemicals, Green River, WY Tenneco, Green River, WY
Titanium Tetrachloride	du Pont, Pass Christian, MS* du Pont, Edgemoor, DE* Kemira, Savannah, GA* SCM, Baltimore, MD* Timet, Henderson, NV*
Zinc	Zinc Corp. of America, Monaca, PA* Zinc Corp. of America, Bartlesvill, OK

* Indicates facilities included within the scope of the Report to Congress.

Appendix B-3

List of Facilities With Documented Cases of Damage from Mineral Processing Waste

Appendix B-3
List of Facilities With Documented Cases of Damage from Mineral Processing Waste[1]

Alumina
Ormet, Burnside, LA

Coal Gasification
Dakota Gasification, Beulah, ND

Copper
ASARCO, El Paso, TX
ASARCO, Commencement Bay, Tacoma, WA
Anaconda, MT
Valley Materials Corporation (Midvale Slag), Midvale, UT

Ferrous Metals
LTV Steel, Aliquippa, PA

Hydrofluoric Acid
Allied-Signal, Geismar, LA

Lead
Doe Run, Boss, MO
ASARCO, Glover, MO
ASARCO, E. Helena, MT
ASARCO, El Paso, TX
Valley Materials Corporation (Midvale Slag), Midvale, UT

Phosphoric Acid
Gardinier, East Tampa, FL
Seminole, Bartow, FL
Central Phosphates, Plant City, FL
Texasgulf, Aurora, NC
Arcadian, Geismar, LA
Agrico, Donaldsonville, LA
Nu-West, Caribou, ID

Zinc
Zinc Corporation of America (Palmerton Zinc), Palmerton, PA
Zinc Corporation of America, DePue, IL
ASARCO, Columbus, OH
ASARCO, El Paso, TX

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[1] Facilities are listed under each sector for which there is a documented case of danger.

Appendix B-4

Example of RCRA §3007 Data Request

Office of
Solid Waste and Emergency Response

OMB # 2050-0092
Expires: 12/89

Name
Address

Dear Sir:

The U.S. Environmental Protection Agency (EPA) is gathering data on selected mineral processing wastes. Currently, solid wastes from mineral processing operations are excluded from regulation under Subtitle C of the Resource Conservation and Recovery Act (RCRA), as amended, [see 40 CFR 261.4(b)(7)]. On July 29, 1988, the U.S. Court of Appeals for the District of Columbia Circuit directed EPA to narrow the scope of this exclusion and complete the Report to Congress required by Section 8002(p) of RCRA for the wastes that remain excluded under the narrower scope. [Environmental Defense Fund v. EPA, 852 F. 2d 1316 (D.C. Cir. 1988)]. The data that EPA is gathering are needed by the Agency to help determine which processing wastes will remain within the exclusion and be studied in the Report to Congress. In addition, the data will be used in preparation of the Report to Congress.

As part of this data gathering effort, EPA recently mailed your firm the "National Survey of Solid Wastes from Mineral Processing Facilities" (OMB # 2050-0098). The survey is designed primarily to collect information on the generation and management of selected wastes at your ________ processing facility. This letter is intended to gather additional information -- data on waste characteristics.

EPA is requesting that you submit all existing data collected since January 1, 1984 on the physical (e.g., solids content or percent moisture, particle size) and chemical composition (i.e., presence and concentration of elements and compounds included in 40 CFR Part 264, Appendix IX), radioactivity, and pH (if applicable) of any of the following wastes generated at your processing facility:

- [slag, process wastewater, air pollution control dust/ sludge, etc.]

Existing data from extraction-type tests is also requested. In particular, the Agency is interested in the results of any synthetic precipitation leach tests (method 1312) and Extraction Procedure (EP) toxicity tests (method 1310) that have been performed (see "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," third edition, SW-846). However, the Agency also requests data from any other extraction-type tests that have been performed.

You are requested to submit hard copies of the appropriate data within two weeks of receiving this letter. All data submitted should clearly indicate the type of waste to which they apply, the date the sample was collected, and the analytical method(s) used.

In the event that you have few or none of the existing data being requested, or you have reason to believe that the existing data are not representative of the waste that you currently generate, you may wish to voluntarily collect new data through sampling and analysis. If you choose to collect new data, you must notify the Agency of your intention to do so within two weeks of receiving this letter. These new data must be developed using the methods found in the third edition of "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846. In addition, the data must be received by the Agency no later than 60 calendar days after receipt of this letter.

We are requesting this information under authority of Section 3007 of RCRA. Failure to respond to this information request within the specified amount of time may lead to penalties under Section 3008(a). In addition, information obtained under RCRA Section 3007 must be made available to the public unless you demonstrate to EPA that it is confidential. The treatment of confidential business information is provided for by Section 3007(b) of RCRA and regulations contained in 40 CFR Part 2.

If you have any questions in response to this inquiry, please contact Bob Hall at (202) 475-8814. We look forward to your response.

Sincerely,

David Bussard
Acting Director
Waste Management Division

Existing data from extraction-type tests is also requested. In particular, the Agency is interested in the results of any synthetic precipitation leach tests (method 1312) and Extraction Procedure (EP) toxicity tests (method 1310) that have been performed (see "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," third edition, SW-846). However, the Agency also requests data from any other extraction-type tests that have been performed.

You are requested to submit hard copies of the appropriate data within two weeks of receiving this letter. All data submitted should clearly indicate the type of waste to which they apply, the date the sample was collected, and the analytical method(s) used.

In the event that you have few or none of the existing data being requested, or you have reason to believe that the existing data are not representative of the waste that you currently generate, you may wish to voluntarily collect new data through sampling and analysis. If you choose to collect new data, you must notify the Agency of your intention to do so within two weeks of receiving this letter. These new data must be developed using the methods found in the third edition of "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846. In addition, the data must be received by the Agency no later than 60 calendar days after receipt of this letter.

We are requesting this information under authority of Section 3007 of RCRA. Failure to respond to this information request within the specified amount of time may lead to penalties under Section 3008(a). In addition, information obtained under RCRA Section 3007 must be made available to the public unless you demonstrate to EPA that it is confidential. The treatment of confidential business information is provided for by Section 3007(b) of RCRA and regulations contained in 40 CFR Part 2.

If you have any questions in response to this inquiry, please contact Bob Hall at (202) 475-8814. We look forward to your response.

Sincerely,

David Bussard
Acting Director
Waste Management Division

Appendix B-5

List of Published Reports, Papers, Abstracts, and Data

Appendix B-5
List of Published Reports, Papers, Abstracts, and Data

This bibliography contains many of the documents (e.g., journal articles, reports, surveys, trip reports, and miscellaneous correspondence) which contributed to the Agency's understanding of the waste streams under consideration. This is not a complete inventory of the documents cited in the report, and some of the documents reported in this bibliography are not cited in the report. Documents which only contain information on a single sector are organized by sector, in the same order as the chapters of the report. Documents with information on more than one sector are located at the end of the bibliography under the heading "Multisector Documents".

Alumina

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Appendix C

Risk Assessment Criteria and Model

Appendix C-1

Risk Assessment Screening Criteria

Appendix C-1

Risk Assessment Screening Criteria

As described in Section 2.2.2 of Volume II of this report, EPA began its risk assessment of mineral processing wastes by assessing the intrinsic hazard of each waste stream. The Agency assessed intrinsic hazard by comparing the concentrations of chemical and radioactive contaminants in each waste and waste leachate to a series of conservative screening criteria. Concentrations above the screening criteria were interpreted as an indication that the wastes conceivably could pose risk to human health or the environment under a set of very conservative, hypothetical release and exposure conditions -- exceedances of the criteria should not, in isolation, be interpreted as proof of hazard. If any sample of a waste from any facility contained a contaminant concentration in excess of a screening criterion, EPA used that as a basis for proceeding to the next step of the assessment to evaluate the site-specific factors that influence the waste's risk in more detail. Contaminants that never exceeded a screening criterion were dropped from further analysis.

Section 2.2.2 describes the rationale and process for developing the different categories of screening criteria. This appendix lists the specific numerical values that were used as criteria, as well as the regulatory or toxicological benchmarks upon which the criteria were based. In particular, the appendix provides the following four exhibits:

1. Exhibit C-1-1, Human Health Screening Criteria for Comparison to Liquid/Leachate Samples;
2. Exhibit C-1-2, Resource Damage Screening Criteria for Comparison to Liquid/Leachate Samples;
3. Exhibit C-1-3, Aquatic Ecological Screening Criteria for Comparison to Liquid/Leachate Samples; and
4. Exhibit C-1-4, Screening Criteria for Comparison to Solid Samples.

Exhibit C-1-1
Human Health Screening Criteria for Comparison to Liquid/Leachate Samples

	Drinking Water Benchmarks			
Constituent	Cancer Benchmark[a] (µg/L)	Noncancer Benchmark[b] (µg/L)	Associated Noncancer Effect	Human Health Screening Criterion (µg/L)
Aluminum				–[c]
Antimony		14	Cardiac effects	140
Arsenic	0.2	35	Dermal effects	2
Barium		1,800	High blood pressure	18,000
Beryllium		180	Decreased growth	1,800
Boron		3,200	Adv. effect to repro. organs	32,000
Cadmium		18	Renal effects	180
Chloride				–
Chromium (VI)		180	Kidney, liver damage[d]	1,800
Cobalt				–
Copper		1,300	GI irrigation	13,000
Fluoride		2,100	Dental fluorosis	21,000
Gross alpha				–
Gross beta				–
Iron				–
Lead		21	Neurotoxicity	210
Magnesium				–
Manganese		7,000	CNS effects	70,000
Mercury		10	CNS effects	100
Molybdenum				–
Nickel		700	Decreased weight	7,000
Nitrite		3,500	Methemoglobenemia	35,000
Nitrate		35,000	Methemoglobenemia	350,000
pH				–
Phosphate (Total)				–
Phosphorus				–
Radium-226	1.6 pCi/L			16 pCi/L
Selenium		110	Dermal, neuro. effects	1,100
Silver		110	Skin discoloration	1,100
Sulfate				–
Suspended solids				–
Thallium		2.5	CNS effects[d]	25
Thorium-232	9.1 pCi/L			91 pCi/L
Uranium-238	1.5 pCi/L			15 pCi/L
Vanadium		250	Liver, bone marrow damage[d]	2,500
Zinc		7,000	Hematological effects	70,000

(a) Concentrations represent a lifetime cancer risk of 1×10^{-5}. The arsenic concentration was derived from the cancer slope factor presented in the Integrated Risk Information System (IRIS). The radionuclide concentrations were estimated based on cancer slope factors developed by EPA's Office of Radiation Programs for inclusion in the Health Effects Assessment Summary Tables (HEAST).

(b) Derived from chronic reference doses (RfDs) presented in IRIS, with the exception of lead. For lead, an RfD of 0.0006 mg/kg-day was independently derived based on available toxicological data.

(c) No screening criterion used because of lack of toxicological benchmarks.

(d) Acute effects (no chronic effects at these concentrations).

Exhibit C-1-2
Resource Damage Screening Criteria for Comparison to Liquid/Leachate Samples

Constituent	Benchmark (µg/L)	Basis for Benchmark	Resource Damage Screening Criterion (µg/L)
Aluminum	5,000	Continuous irrigation guide[(a)]	50,000
Antimony	45,000	AWQC for fish ingestion[(b)]	4,500,000
Arsenic	50	Primary MCL[(c)]	500
Barium	1,000	Primary MCL	10,000
Beryllium	1.2	AWQC for fish ingestion	120
Boron	750	Continuous irrigation guide	7,500
Cadmium	10	Primary MCL	100
Chloride	250,000	Secondary MCL	2,500,000
Chromium(VI)	50	Primary MCL	500
Cobalt	50	Continuous irrigation guide	500
Copper	1,300	Secondary MCL (proposed)	13,000
Fluoride	4,000	Primary MCL	40,000
Gross alpha	15 pCi/L	Primary MCL[(d)]	150 pCi/L
Gross beta	50 pCi/L	Primary MCL[(d)]	500 pCi/L
Iron	300	Secondary MCL	3,000
Lead	5	Primary MCL (proposed)	50
Magnesium			–[(e)]
Manganese	50	Secondary MCL	500
Mercury	2	Primary MCL (proposed)	20
Molybdenum	10	Continuous irrigation guide	100
Nickel	200	Continuous irrigation guide	2,000
Nitrite	1,000	Primary MCL	10,000
Nitrate	10,000	Primary MCL	100,000
pH	6.5-8.5	Secondary MCL	6.5-8.5
Phosphate(Total)			–
Phosphorus			–
Radium-226	5 pCi/L	Primary MCL[(d)]	50 pCi/L
Selenium	10	Primary MCL	100
Silver	50	Primary MCL	500
Sulfate	250,000	Secondary MCL	2,500,000
Suspended solids			–
Thallium	46	AWQC for fish ingestion	4,600
Thorium-232			–
Uranium-238			–
Vanadium	100	Continuous irrigation guide	1,000
Zinc	5,000	Secondary MCL	50,000

(a) Maximum concentrations recommended by the National Academy of Sciences in "Water Quality Criteria – 1972." These concentrations are generally set at levels less than the concentrations that are toxic to sensitive plants when grown in sandy soils.

(b) Ambient Water Quality Criteria (AWQC), as taken from EPA chemical-specific source documents, designed to protect against adverse human health effects caused by the ingestion of fish. For beryllium, the benchmark presented here is designed to limit cancer risks to a level of 1x10^{-6}.

(c) Drinking water maximum contaminant level (MCL).

(d) The MCL for gross alpha radiation excludes radon and uranium. No MCL for gross beta radiation has been issued; however, compliance with 40 CFR 141.16 may be assumed if gross beta concentrations are less than 50 pCi/L. The MCL for radium is 5 pCi/L for combined radium-226 and radium-228.

(e) No screening criterion used because of lack of relevant benchmarks.

Exhibit C-1-3
Aquatic Ecological Screening Criteria for Comparison to Liquid/Leachate Samples

Constituent	Benchmark (μg/L)	Basis for Benchmark	Aquatic Ecological Screening Criterion (μg/L)
Aluminum	87	Freshwater chronic AWQC(a)	8,700
Antimony	1,600	Freshwater chronic AWQC	160,000
Arsenic	13	Saltwater chronic AWQC(b)	1,300
Barium	50,000	Freshwater chronic guide(c)	5,000,000
Beryllium	5.3	Freshwater chronic AWQC	530
Boron	5,000	Saltwater chronic guide	500,000
Cadmium	1.1	Freshwater chronic AWQC	110
Chloride	230,000	Freshwater chronic AWQC	23,000,000
Chromium(VI)	11	Freshwater chronic AWQC	1,100
Cobalt			–(d)
Copper	2.9	Saltwater chronic AWQC	290
Fluoride			–
Gross alpha			–
Gross beta			–
Iron	1,000	Freshwater chronic AWQC	100,000
Lead	3.2	Freshwater chronic AWQC	320
Magnesium(e)			–
Manganese	1,000	Freshwater chronic guide	100,000
Mercury	0.012	Freshwater chronic AWQC	1.2
Molybdenum			–
Nickel	8.3	Saltwater chronic AWQC	830
Nitrite	60	Freshwater chronic guide	6,000
Nitrate	90,000	Freshwater chronic guide	9,000,000
pH	6.5-9	Freshwater chronic AWQC	6.5-9
Phosphate(Total)	25-100	Freshwater chronic guide(f)	2,500-10,000
Phosphorus	0.1	Saltwater chronic AWQC	10
Radium-226			–
Selenium	5	Freshwater chronic AWQC	500
Silver	0.12	Freshwater chronic AWQC	12
Sulfate(e)			–
Suspended solids	25,000	Freshwater chronic guide	2,500,000
Thallium	40	Freshwater chronic AWQC	4,000
Thorium-232			–
Total Dissolved Solids(e)	5,000,000	Freshwater chronic guide	500,000,000
Uranium-238			–
Vanadium	1,280	Freshwater acute guide	128,000
Zinc	86	Saltwater chronic AWQC	8,600

(a) Ambient Water Quality Criteria (AWQC), as taken from EPA chemical-specific source documents, designed to protect freshwater organisms against harmful chronic exposures.

(b) AWQC, as taken from EPA chemical-specific source documents, designed to protect saltwater organisms against harmful chronic exposures.

(c) Not official AWQC, but independently developed based on the toxicological literature.

(d) No screening criterion used because of lack of toxicological benchmarks and data.

(e) Total dissolved solids figure for magnesium plus sulfate.

(f) Benchmarks for phosphate are 25 μg/L within a lake or reservoir, 50 μg/L in any stream at the point where it enters a lake or reservoir, and 100 μg/L in streams or other flowing waters not discharging directly to lakes or impoundments.

Exhibit C-1-4
Screening Criteria for Comparison to Solid Samples

Constituents	Soil Ingestion Screening Criteria			Particulate Inhalation Screening Criteria[d]		
	Cancer Benchmark[a] (µg/g)	Noncancer Benchmark[b] (µg/g)	Associated Noncancer Effect	Cancer Benchmark[a] (µg/g)	Noncancer Benchmark[b] (µg/g)	Associated Noncancer Effect
Aluminum						
Antimony		280	Cardiac effects			
Arsenic	4	700	Dermal effects	14		
Barium		35,000	Increased blood pressure		7,000	Fetotoxicity
Beryllium		3,500	Decreased growth	84		
Boron		63,000	Adverse effect to reproductive organs			
Cadmium		350	Renal effects	115		
Chloride						
Chromium(VI)		3,500	Kidney, liver damage[c]	17		
Cobalt						
Copper		25,900	GI irritation			
Fluoride		42,000	Dental fluorosis			
Gross alpha						
Gross beta						
Iron						
Lead		420	Neurotoxicity			
Magnesium						
Manganese		140,000	CNS effects		21,000	CNS effects
Mercury		210	CNS effects			
Molybdenum						
Nickel		14,000	Decreased weight	833		
Nitrite		70,000	Methemoglobenemia			
Nitrate		700,000	Methemoglobenemia			
pH						
Phosphate (Total)						
Phosphorus						
Radium-226				134 pCi/g[e]		
Selenium		2,100	Dermal, neurological effects		80	Dermatitis, GI disturbance
Silver		2,100	Skin discoloration			

Exhibit C-1-4 (cont'd)
Screening Criteria for Comparison to Solid Samples

Constituents	Soil Ingestion Screening Criteria			Particulate Inhalation Screening Criteria[d]		
	Cancer Benchmark[a] (µg/g)	Noncancer Benchmark[b] (µg/g)	Associated Noncancer Effect	Cancer Benchmark[a] (µg/g)	Noncancer Benchmark[b] (µg/g)	Associated Noncancer Effect
Sulfate						
Suspended Solids						
Thallium		49	CNS effects[c]			
Thorium-232				13 pCi/g[e]		
Uranium-238				17 pCi/g[e]		
Vanadium		4,900	Liver, bone marrow damage[c]			
Zinc		140,000	Hematological effects			

[a] Concentrations presented represent a lifetime cancer risk of 1×10^{-6}. These concentrations were derived from cancer slope factors presented in the Integrated Risk Information System (IRIS), with the exception of the radionuclides and nickel. The radionuclide concentrations were estimated based on cancer slope factors developed by the Office of Radiation Programs for inclusion in the Health Effects Assessment Summary Tables (HEAST). The nickel concentration for the particulate inhalation pathway was estimated based on a cancer slope factor in the HEAST.

[b] Derived from chronic reference doses (RfDs) presented in IRIS, with the exception of lead, barium, and manganese. For lead, an RfD of 0.0006 mg/kg-day was independently derived based on available toxicological data. For barium and manganese (particulate inhalation pathway only), RfDs were taken from the HEAST.

[c] Acute effects (no chronic effects at these concentrations).

[d] Concentrations for particulate inhalation pathway were estimated based on the assumption that the airborne particulate concentration is 50 µg/m^3. This particulate concentration is the National Ambient Air Quality Standard (annual arithmetic mean) for particulate matter.

[e] These radionuclide concentrations relate only to the risk caused by the inhalation of each of the radionuclides by themselves. They do not account for other exposure pathways (e.g., direct radiation) or for the inhalation of radioactive decay products.

Exhibit C-1-4 (cont'd)
Screening Criteria for Comparison to Solid Samples

Constituents	Radiation Exposure Screening Criteria		Air Resource Damage Screening Criterion	
	Benchmark (pCi/g)	Basis	Benchmark (µg/g)	Basis
Radium-226	5	EPA cleanup standard for uranium mill tailings(f)		
Thorium-232	10	NRC cleanup guide(g)		
Uranium-238	10	NRC cleanup guide(g)		
Lead			30,000	Could result in exceedance of NAAQS(h)

(f) This standard, provided in 40 CFR 192, applies to the top 15 centimeters of soil. It is designed to limit the risk from inhalation of radon decay products in houses built on contaminated land, and to limit gamma radiation exposures of people using contaminated land.

(g) Nuclear Regulatory Commission (NRC) recommended cleanup limit presented in "Disposal or Onsite Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present) from Past Operations." These limits, which are based on the assumption that U-238 and Th-232 are in secular equilibrium with their respective decay products, are based on EPA's standard in 40 CFR 192; the concentrations are believed to be acceptably low, making it unnecessary for the NRC to restrict the method of burial.

(h) Calculated based on the assumption that the airborne particulate concentration is 50 $\mu g/m^3$, the National Ambient Air Quality Standard (annual arithmetic mean) for particulate matter.

Appendix C-2

Summary of MMSOILS Model

Appendix C-2
Summary of MMSOILS Model

Introduction

MMSOILS is a multimedia exposure and risk estimation model that was originally developed by EPA's Office of Research and Development (ORD). The model is a screening tool designed to assist EPA in setting priorities for hazardous waste management.

MMSOILS was designed to estimate exposures and health risks associated with the release and subsequent fate and transport of chemicals from contaminated soils. The four basic functions of the multimedia methodology are to:

(1) Estimate chemical release rates from the soil into various environmental media (air, ground water, surface water, food sources), based on chemical properties and land use at the site;

(2) Estimate the chemical concentration at exposure points in each environmental media considered, based on the chemical release rate and the proximity to exposed populations;

(3) Estimate human exposures through inhalation, ingestion, and absorption based on the chemical concentration at exposure points and assumptions regarding human intake levels; and

(4) Estimate the potential health risk based on toxicity data for the specific chemical, based on toxicity data for the chemical and the estimated human exposures at exposure points.

MMSOILS has been used for comparison with an EPA dioxin exposure assessment document (EPA 1988), with favorable results. It also has undergone extensive peer review by several offices of EPA and members of the academic community. The model documentation (ICF Technology, Inc. 1989) provides more detailed description of MMSOILS.

Adaptations for the Mineral Processing Waste Risk Assessment

The mineral processing waste risk assessment required modeling of multiple chemicals released from a variety of waste containment units, not just contaminated soil. MMSOILS was identified as an appropriate model for the task, but three major model modifications were required.

First, algorithms for predicting contaminant releases from waste management units such as waste piles, landfills, surface impoundments, and injection wells, were added. As part of this change, the water balance component, which accounts for precipitation, evapotranspiration, and recharge, was revised to accommodate changes in the waste management units with time, such as the installation of a cap on a landfill, or the gradual failure of a liner. MMSOILS now allows the user to specify a cover and liner design, and the magnitude and timing of waste containment failure. Cover designs include vegetative, clay, and RCRA cap. Liner designs include unlined, clay, single synthetic, composite (clay, membrane, and collection system), and a double liner that meets minimum technology requirements of HSWA Section 3004(o). The user can specify up to five independent failure events throughout the simulation period.

Second, a selection of leachate quality algorithms was added. While the liner/cover design and failure/release components of the model estimate the quantity of leachate released each year from a waste management unit, the leachate quality algorithms estimate the contaminant concentrations in the waste leachate. These algorithms are dependent upon the waste management unit chosen. There are three mathematical approaches available for waste piles, landfills, and surface impoundments. As a matter of practice in the mineral processing waste risk assessment, however, leachate quality was modeled as steady-state contaminant concentrations that equal the median concentrations measured in extraction procedure leach tests (as discussed in Chapter 2 of this report).

Third, MMSOILS was expanded to process multiple chemicals. Concentrations and resulting risks of individual contaminants can be calculated for each desired pathway, and an overall risk can be summed across constituents.

Overview of Major Release and Transport Modules

MMSOILS is divided into five distinct transport pathways: atmospheric, surface water, ground water, soil erosion, and food chain bio-accumulation.

The Atmospheric Pathway

The atmospheric pathway is simulated if the potential for airborne releases exists at the site. The atmospheric pathway component of the model considers the release of contaminants from the site in the form of vapors and fugitive dust emissions from wind erosion and mechanical disturbances (however, with the exception of the coal gasification wastes, only dust releases were relevant for the mineral processing waste risk assessment). Once the contaminant is in the atmosphere, it is transported by wind and dispersed due to turbulence in the flow. MMSOILS represents the following processes: volatilization from soils, volatilization from a water body, particulate emissions due to wind erosion and mechanical disturbances, atmospheric transport and dispersion, and atmospheric deposition.

The equation used in MMSOILS for estimating the release of windblown dust assumes that there is an "unlimited reservoir" of erodible particles. This equation (adapted from EPA 1985) is an empirical relationship of field and climatic factors that was developed based on field measurements of dust releases from sandy agricultural soils. Therefore, application of this release equation to many of the mineral processing wastes studied in this report is very conservative (i.e., it tends to overpredict releases). Many of the mineral processing wastes actually contain a "limited reservoir" of erodible material, consisting of a mixture of erodible and non-erodible elements such as large particles or fragments on the surface. These non-erodible elements consume part of the shear stress of the wind that otherwise would be transferred to erodible particles.

The Surface Water Pathway

The surface water pathway needs to be simulated if there is a potential for contaminants to leave the site via run-off into surface water or discharge of affected ground water. The surface water pathway component of the model evaluates contaminants entering one of two types of receiving water bodies, a stream/river or a small lake. For contaminants entering a small lake, the source term is the contaminated bed sediments resulting from the erosion of contaminated particles (either waste material or soil) from an adjacent waste site. The potential source terms incorporated in the model for contaminants entering a stream include the erosion of contaminants adsorbed to the solid particles and the discharge of contaminated groundwater into the stream. The potential source term of contaminant dissolved in surface run-off from the site entering a stream or a lake is not addressed in the model. Once contaminants have reached the water body, a concentration in the water is estimated by assuming that the contaminants are completely mixed in the water's flow.

In the mineral processing waste risk assessment, EPA's surface water modeling considered only the chronic (i.e., steady-state) loading of contaminants to surface waters. Monthly average precipitation rates and annual average surface water flow rates were used as model inputs. The Agency did not model larger short-term releases, such as those associated with large storms, that could result in higher contaminant concentrations that last for shorter durations.

The Ground-Water Pathway

The ground-water pathway is simulated if there is a potential for contaminants to be transported through the unsaturated and saturated ground-water systems. The ground-water pathway component of the model examines the net recharge, leaching of contaminants from the soil, transport through the partially saturated zone, and contaminant transport/dispersion within an aquifer. Recharge is calculated using a yearly water balance, which adds system inputs (such as precipitation and irrigation) and subtracts outputs (such as run-off and evapo-transpiration). Landfills, waste piles, and surface impoundments each have three options available for calculating contaminant leaching. Flow through the partially saturated zone is assumed to be steady state, and one dimensional. The fate and transport of a contaminant in an aquifer is estimated based on a quasi-analytical solution to the advection dispersion equation incorporating retardation and first order decay.

The Soil Erosion Pathway

The soil erosion pathway is analyzed if there is a potential for contaminated soil to be eroded off-site to potential exposure points. The soil erosion pathway component of the model is used to evaluate contaminant movement to off-site soils though two mechanisms: soil erosion and atmospheric deposition. Although atmospheric deposition is not related to soil erosion processes, the effect of atmospheric deposition is included at this point in the model since it is a mechanism by which off-site soils may become contaminated. MMSOILS represents soil erosion from a site, delivery fraction of eroded soil and mixing with off-site soils, and soil contamination due to atmospheric deposition.

The Food Chain Pathway

The food chain bio-accumulation pathway needs to be simulated if there exists a potential for contaminants to enter the food chain. The food chain bioaccumulation pathway component of the model uses the transport of contaminants from the site via other environmental transport pathways as the source term(s). Examples of environmental transport pathways that may serve as the source terms for the food chain pathway include atmospheric transport and deposition, soil erosion, and migration within ground-water and subsequent use for irrigation. Based on these source terms, the food chain pathway component examines the accumulation of a chemical within fish, terrestrial plants, and cattle. Simple representations of bioaccumulation using bioconcentration factors and transfer factors are used in MMSOILS. The bioconcentration factors are used to represent the partitioning of a chemical between: (1) water and fish, (2) edible parts of terrestrial plants and soil, and (3) root vegetables and soil moisture. The transfer factors are used to represent the uptake of chemical by animals as a function of the mass of chemical ingested in feed and water.

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Appendix D

Existing Regulatory Controls

Appendix D-1

Existing Federal Regulatory Controls Addressing Mineral Processing Wastes

Appendix D-1
Existing Federal Regulatory Controls Addressing Mineral Processing Wastes

1. Applicable Federal Regulations

While temporarily excluding all "[s]olid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under RCRA Subtitle C provisions, the 1980 Bevill amendment did not preclude their regulation under "other provisions of federal or state law...." This includes their current regulation under Subtitle D of RCRA and a variety of other federal and state air quality, water quality, and solid and hazardous waste management requirements. Pending development of a RCRA Subtitle D program that addresses mining wastes, EPA has stated its intention to use Section 7003 of RCRA and Sections 104 and 106 of CERCLA "to protect against substantial threats and imminent hazards" (51 FR 24496). These provisions are mentioned under the discussions of RCRA and CERCLA, below.

Legal requirements vary, depending on the waste(s) or waste constituent involved, and the ownership -- public or private -- of the land involved. This appendix provides an overview of potentially applicable federal laws, and the provisions that relate to the disposition of ore processing wastes.

2. Summary of Federal Laws and Regulations

There are several federal statutes that directly and indirectly affect the disposition of mineral processing wastes. The key laws and responsible agencies are listed in Exhibit D-1-1. The important provisions of these federal laws and their associated regulations as they relate to the management and disposal of special wastes from mineral processing are summarized below.

3. Hazardous Waste

RCRA Subtitle C

In 1976, Congress enacted the Resource Conservation and Recovery Act (RCRA), which established comprehensive requirements for the management of solid and hazardous wastes. Specific requirements for hazardous wastes are found in Subtitle C of RCRA. Subtitle C provides a statutory framework for tracking all hazardous and toxic wastes from "cradle to grave," that is, from their generation to their final disposal, destruction, or recycling.

Pursuant to regulations issued by EPA (40 CFR Part 261), solid wastes which meet EPA hazardous waste criteria with respect to "toxicity, persistence, degradability in nature, potential for accumulation in tissue, and other related factors such as flammability, corrosiveness..." [Section 3001(a)] are subject to the statute's labeling, storage, transportation, and disposal requirements.

Generally, some mineral processing solid wastes would otherwise qualify as hazardous wastes under RCRA. However, pursuant to the statute's provisions under Section 3001(b)(3)(A)(ii), "[s]olid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore" are conditionally exempt from regulation under Subtitle C. EPA may respond to a waste management situation that presents "an imminent and substantial endangerment to health or the environment" under the authority of Section 7003 of RCRA. Actions sanctioned by Section 7003 include filing suit on behalf of the United States to order the violator to stop the activity, as well as the

Exhibit D-1-1
Federal Laws Applicable to Mineral Extraction, Beneficiation, and Processing Wastes

Number	Statute	Regulations	Lead Agency[*]
642 USC 6901-6991i	The Resource Conservation and Recovery Act of 1976 (RCRA), as amended by the Hazardous and Solid Waste Act of 1984 (HSWA)	40 CFR 255-280	EPA
42 USC 9601-9675	The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA)	40 CFR 300-306	EPA
33 USC 1251-1376	The Federal Water Pollution Control Act (FWPCA), as amended by the Clean Water Act (CWA) of 1977 and the Water Quality Act of 1987 (WQA)	40 CFR 122, 123, 125, 130, 131, 230, 231, 403, 415, 418, 420, 421, 422, 436	EPA
42 USC 300f-300j-11	The Safe Drinking Water Act of 1984 (SDWA), as amended by the SDWA amendments of 1986	40 CFR 141-149	EPA
42 USC 7401-7641	The Clean Air Act of 1970 (CAA), as amended by the CAA amendments of 1977	40 CFR 50, 57, 60, 61	EPA
42 USC 4341	The National Environmental Policy Act of 1969 (NEPA)	40 CFR 6, 1500-1508	EPA
43 USC 1701	The Federal Land Policy and Management Act of 1976 (FLPMA)	43 CFR 3801-3870 (BLM)	DOI

* EPA:	Environmental Protection Agency
DOI:	Department of the Interior
BLM:	Bureau of Land Management

commencement of necessary actions for cleanup or the issuance of administrative orders as may be necessary to protect public health and the environment.

Of the states analyzed in this report, only three do not have EPA approved programs for regulating Subtitle C wastes. California, Idaho, and Ohio do not have primacy for Subtitle C, and therefore, mineral processing operations in these states are subject to the above federal regulations.

Superfund

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or Superfund, was enacted to provide the federal government with the authority and resources to respond to situations in which pollutants or contaminants are or may be released into the environment such that they pose an "imminent and substantial danger to the public health or welfare..." (Section 104). Uncontrolled run-off, leachates, and other air and water emissions, or releases from ore processing facilities that are not authorized by permits under other federal and/or state laws can be subject to the regulatory and liability provisions of the statute.

CERCLA authorizes EPA to respond to immediate threats to the environment or human health in situations where a responsible party cannot act or cannot be readily identified. EPA has stated its intent to use CERCLA response and abatement authorities, Sections 104 and 106, to respond to imminent hazard situations at mineral production sites if required (51 FR 24496). In such situations, EPA can proceed with necessary containment or removal actions. Where conditions allow, the Agency can also undertake more detailed remedial investigation and feasibility studies of abandoned or inactive waste sites necessary for the design and execution of long term remedial actions. Section 106 provides authority for orders necessary to protect public health and welfare and the environment and provides enforcement authority as well.

In those situations where responsible parties that can respond "properly and promptly" can be identified, EPA is authorized to establish what remedial actions are required and to oversee the responsible parties' cleanup efforts. In all cases, the owners and/or other responsible parties are liable for the costs of cleaning up the hazardous waste problem, and for correcting damages to affected natural resources (Section 107).

Under the law, EPA is required to establish and periodically update a National Contingency Plan (NCP, Section 105) which includes, among other things:

> [C]riteria for determining priorities among releases or threatened releases throughout the United States for the purposes of taking remedial action and, to the extent practicable taking into account the potential urgency of such action, for the purpose of taking removal action. Criteria and priorities...shall be based upon relative risk or danger to public health or welfare or the environment...taking into account to the extent possible the population at risk, the hazard potential of the hazardous substances at such facilities, the potential for contamination of drinking water supplies, the potential for direct human contact, the potential for destruction of sensitive ecosystems, the damage to natural resources which may affect the human food chain...the contamination or potential contamination of the ambient air...[Section 105 (a)(8)(A)].

These criteria have been incorporated into a hazard ranking system (HRS) which is used to evaluate uncontrolled hazardous waste sites around the country, and to rank them according to degree of overall hazard. Sites that receive HRS scores greater than 28.5 are listed on the National Priorities List (NPL) which makes them eligible for federal funding of additional remedial response activities.

Pursuant to the amendments to CERCLA -- the Superfund Amendments and Reauthorization Act of 1986 (SARA) -- EPA must further revise the NCP to "assure, to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review" [Section 105(c)]. SARA also requires that, pending revision of the HRS, the addition of any uncontrolled hazardous waste sites containing "significant quantities" of mining wastes -- i.e., special study wastes under RCRA Section 3001(b)(3)(A) (including wastes from materials generated from the extraction, beneficiation, and processing of ores and minerals), or other special study wastes -- to the NPL must take into account the following factors:

> (1) The extent to which the hazard ranking system score for the facility is affected by the presence of any special study waste at, or any release from, such facility.
>
> (2) Available information as to the quantity, toxicity, and concentration of hazardous substances that are constituents of any special study waste at, or released from such facility, the extent of or potential for release of such hazardous constituents, the exposure or potential exposure to human population and the environment, and the degree of hazard to human health or the environment posed by the release of such hazardous constituents at such facility. This subparagraph refers only to available or actual concentrations of hazardous substances and not to the total quantity of special study waste at such facility [Section 105(g)(2)].

A proposed rule modifying the Hazard Ranking System was published in the *Federal Register* in December, 1988, and is being finalized at this time.

The SARA legislation also requires that for facilities at which hazardous wastes are left on-site, the remedial cleanup plan must ensure that all "legally applicable" federal and state standards that may exist for the hazardous substances in question are achieved [Section 121(d)(2)(A)].

4. Solid Waste

RCRA Subtitle D

Non-hazardous solid waste is regulated under Subtitle D of RCRA. Ore and mineral extraction, beneficiation, and processing operations generally involve the generation, transport, storage, treatment, and disposal of a wide variety of solid wastes including; overburden, waste rock, tailings, lubricants, solvents, chemical reagents, refuse, and sewage.

Wastes generated from the extraction, beneficiation, and processing of ores and minerals (i.e. hard-rock, non-fuel mining operations) were temporarily excluded, pending further study, from regulation under the RCRA Subtitle C hazardous waste program by Section 3001 of RCRA (i.e., the Bevill exclusion) in 1980. Following the release of a Report to Congress in 1985, EPA made a regulatory determination in 1986 (51 FR 24496) that all of the wastes addressed by the 1985 Report to Congress would be regulated under Subtitle D of RCRA rather than Subtitle C because of the relatively large volume, low hazard nature of those wastes. EPA determined further that it would develop a new program under Subtitle D that would be flexible, site-specific, risk-based, and tailored otherwise to address these mining wastes specifically, rather than relying on existing Subtitle D programs. EPA is in the early stages of developing such a regulatory program and has included one possible form of a risk-based, tailored, regulatory program for mineral industry wastes in this report for analytical purposes (see Appendix E-2).

While there is not yet a federal program in place to address mineral industry wastes under Subtitle D, many states have developed Subtitle D programs for future EPA approval. While desirable, the adoption of a state solid waste program which meets minimum requirements specified by the Act is not mandatory. If a state refuses to adopt and enforce its own solid waste management program, EPA currently has no statutory authority to adopt or enforce a federal program in lieu of the state's; it can only withhold funds and technical expertise from the state. Eight states do not as yet have EPA approved Subtitle D plans, including: Idaho, Missouri, Montana, New Mexico, Utah, Maryland, Nevada, and West Virginia. Seven of these states contain one or more facilities that generate special wastes addressed by this report.

The definition of solid waste in the federal solid waste regulations is intended to include wastes generated by the mineral processing industry. According to the federal statute, all wastes must be disposed in compliance with EPA's criteria listed in 40 CFR Part 257.

Waste disposal facilities that meet the criteria in 40 CFR 257.2 are defined as sanitary landfills. Facilities that do not comply with the regulations are defined as open dumps. Open dumping is prohibited under Section 4005 of RCRA. A disposal site such as a tailings pond or waste pile at a mining or processing facility is treated as a "sanitary landfill" or an "open dump." If a site is found to meet EPA's criteria, it could be considered a sanitary landfill and allowed to continue operating. If a disposal site does not meet EPA's criteria, the site could be treated as an "open dump" and must be closed or upgraded in accordance with a compliance schedule outlined by the state.

5. Water Quality

The Clean Water Act

The primary statute for controlling water pollution from mineral processing facilities is the Federal Water Pollution Control Act of 1972, amended in 1977 as the Clean Water Act (CWA). The law establishes the national goals of eliminating the discharge of pollutants into navigable waters and, "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water."

Under the Clean Water Act, "the discharge of any pollutant by any person" from a point source into the surface waters of the nation, except as authorized by a permit, is illegal [Section 301(a)]. Accordingly, any entity seeking to discharge a wastewater effluent to a surface water body must apply for a permit. Permits, which can have terms of up to 5 years, are issued by EPA under the National Pollutant Discharge Elimination System (NPDES) permit program. Title IV of the law establishes permit requirements. Generally, a permit will set forth the specific "effluent limitations" that pertain to specific types of discharges. Permits also usually contain compliance dates and any germane monitoring and reporting requirements.

EPA has approved state programs for implementing the NPDES requirements for all of the states analyzed in this report except for: Arizona, Idaho, New Mexico, Texas, and Louisiana.

Under the law, EPA also has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations" -- expressed in terms of a pollutant concentration, and not the technology itself -- must be established for various classes of industrial discharges, which include a number of mineral processing categories. These limitations are the basis for minimum requirements of NPDES permits. Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). Pursuant to Section 301(b) of the Act, dischargers were required to achieve effluent limitations based on BPT or any more stringent limitation, including those necessary to meet water quality standards, treatment standards, or schedules of compliance, established by state or federal law, by July 1, 1977. Facilities must have achieved effluent limitations based on BAT no later than 3 years after they were established or no later than March 31, 1989.

Exhibit D-1-2 provides relevant citations for applicable effluent guidelines for the twelve commodity sectors discussed in this report.

The CWA also allows EPA to delegate Title IV authority for issuing NPDES permits to qualified states. In such instances, only one state permit need be issued. In states where delegation has not occurred, a federal permit must be obtained. In cases where the state does not have an approved NPDES program, such as Texas, Louisiana, and Idaho, EPA applies the guidelines discussed above. EPA will also adopt any limits necessary to achieve applicable state water quality standards.

The CWA also requires that states establish water quality standards for all surface waters. The standards are subject to EPA approval, and must meet minimum federal criteria. However, states are allowed to set more stringent requirements than those established by EPA. The law allows both EPA and the states to impose "any more stringent [effluent] limitation, including those necessary to meet water quality standards" [Section 301(b)(1)(C)]. The stringency of a particular set of water quality standards, established for stretches or "reaches" of a water course, can significantly affect what will be required to comply with a discharge permit.

Exhibit D-1-2
Federal Regulations Establishing Applicable Effluent Guidelines

Commodity Sector	Regulation	
	Existing Sources	New Sources
Alumina	40 CFR 421	40 CFR 421
Sodium Dichromate	40 CFR 415	40 CFR 415
Coal Gasification	None	None
Primary Copper	40 CFR 421	40 CFR 421
Elemental Phosphorus	None	None
Ferrous Metals	40 CFR 420	40 CFR 420
Hydrofluoric Acid	40 CFR 415	40 CFR 415
Primary Lead	40 CFR 421	40 CFR 421
Magnesium	40 CFR 436	None
Phosphoric Acid	40 CFR 418, 422	40 CFR 418, 422
Titanium Tetrachloride	40 CFR 415	40 CFR 415
Primary Zinc	40 CFR 421	40 CFR 421

If primary processing facilities discharge to publicly-owned treatment works (POTWs), they are subject to pretreatment standards for new and existing sources. Pretreatment standards for new sources from bauxite (alumina), copper, lead, and zinc primary processing facilities are presented in 40 CFR Part 421. Pretreatment standards for existing sources for lead and zinc are also included in 40 CFR Part 421; standards for existing sources for bauxite (alumina) and copper have not been promulgated.

Nonpoint sources of pollution are addressed under the law's Section 208 areawide waste treatment management planning program requirements, which require states to prepare detailed plans for waste management and identification and mitigation of adverse environmental impacts of waste management practices. Nonpoint sources are also specifically addressed by Section 319 of the Clean Water Act Amendments of 1987. Section 319 required states to submit to EPA a program for controlling nonpoint pollution within 18 months of enactment of the amendments. The Act states that in each fiscal year, priority may be given for receipt of federal grant monies to states which have included ground-water protection activities as part of their nonpoint pollution control programs.

Other provisions of the CWA which may affect mineral processing sites are requirements for the disposition of dredged fill materials and waste sludges under Section 404 and controls on the release of oil or hazardous substances under Section 311.

The Safe Drinking Water Act

The Safe Drinking Water Act (SDWA), has several provisions that are significant to mineral processing facilities, including the law's requirements for setting drinking water regulations and Maximum Contaminant Levels (MCLs) for toxic water contaminants, and for regulating underground injection of wastes and protecting sole source aquifers. MCLs are "the maximum permissible level of a contaminant in water which is delivered to any user of a public water system" (Section 1401). EPA is responsible for establishing MCLs for pollutants in drinking water. MCLs for many of the inorganic compounds found at mining waste sites are set forth in 40 CFR 141.11(b). The MCLs for the waste streams analyzed in this report are:

Contaminant	Level in mg/L
Chromium	0.05
Lead	0.05

The MCLs constitute one of the primary classes of applicable and relevant or appropriate requirements (ARARs) that can be used to determine the level of cleanup required at Superfund sites containing mining wastes (see CERCLA Section 122(d)(2)(A)). The SDWA also requires the Agency to establish secondary MCLs; that is, standards that reflect welfare factors such as odor, taste, and color. While these may have little or no direct effect on human health, their violation can be used to justify the abandonment of a water source, or treatment to remedy the problem. For the wastes analyzed in this report, the secondary drinking water standards are:

Contaminant	Level in mg/L
Copper	1
Zinc	5
Iron	0.3
Sulfate	250

Ground water is protected under Part C of the SDWA, "Protection of Underground Sources of Drinking Water," which sets forth requirements for regulating waste disposal through the use of underground injection techniques. Generally, the provision sets criteria for protecting the quality of aquifers used for drinking water from potential contamination from such techniques. EPA regulations pertaining to these provisions of the law can be found at 40 CFR Parts 144-147.

These statutory provisions focus on the use of Underground Injection Control (UIC) techniques, which entail injection of fluids for waste disposal or resource recovery. Well injection is the subsurface emplacement of fluids into any bored, drilled, or driven shaft or dug hole, whose depth is greater than the largest surface dimension (40 CFR 146.03). Five classes of underground injection wells are designated in 40 CFR 144.6:

- Class I - used to inject hazardous waste beneath the lowermost formation containing, within one-quarter mile of the well bore, an underground source of drinking water (USDW);
- Class II - used to inject fluids which are brought to the surface in connection with oil or natural gas recovery or storage operations;
- Class III - used to inject fluids for extraction of minerals, including mining of sulfur by the Frasch process, in situ production of uranium or other metals, or solution mining of salts or potash (includes only solution mining from ore bodies that have not been conventionally mined; solution mining of conventional mines such as stopes leaching is included in Class V);

- Class IV - used to inject hazardous or radioactive waste into or above a formation which within one-quarter mile of the well contains a USDW or into or above a formation which has been exempted pursuant to 40 CFR 146.04 (and therefore is unlikely to ever be used as a drinking water source); and
- Class V - wells not included in the above four classes.

All of these classes of wells must be authorized by permit or rule and no injection may be authorized if it results in movement of fluid containing any contaminant into a USDW (40 CFR Part 146). Existing Class IV wells that inject into a USDW have been phased out and new ones are prohibited (40 CFR 144.13).

Another significant provision of the SDWA's ground-water protection authorities is found in Section 1424, which establishes the process for designating "sole source aquifers." Areas in which an aquifer "is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health" may be designated a sole source aquifer area. Pursuant to the requirements of this provision, once an aquifer is established as a sole source aquifer, the federal government may not make any kind of financial assistance available for any project in the protection area of the aquifer, with the exception of monies that would be used to "plan or design the project to assure that it will not so contaminate the aquifer." Section 1427 of the Act also provides for a "Sole Source Aquifer Demonstration Program," under which states receive financial assistance for establishing sole source aquifer protection areas, and for developing plans to protect such areas. Regulations concerning one such program under this provision can be found at 40 CFR 149.

Provisions for wellhead protection were also adopted as part of the SDWA reauthorization. This legislation established a nation-wide program to encourage states to develop systematic and comprehensive programs within their jurisdictions to protect public water supply wells and wellfields from contamination. To date, twenty-nine states have submitted Wellhead Protection programs for review. Nine states have enacted enabling legislation.

6. Air Quality

The primary statute for preventing and controlling air pollution from mineral processing sites is the Clean Air Act of 1970, as amended in 1977 (42 USC §§ 7401-7626). The major goal of the Clean Air Act is to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population.

In order to achieve its goals, the Clean Air Act establishes a framework to foster programs to prevent and control air pollution, provide technical and financial assistance to state and local governments in connection with the development and execution of air pollution prevention and control programs, and encourage and assist the development and operation of regional air pollution control programs.

Under the authority of the Clean Air Act, EPA has established primary and secondary national ambient air quality standards (NAAQS). Primary standards are intended to protect public health; secondary standards are intended to protect public welfare. NAAQS are established for particulates, sulfur oxides, carbon monoxide, ozone, nitrogen dioxide, and lead. Particulates and sulfur oxides are of special concern to the mineral processing industry.

States are required to prepare State Implementation Plans (SIPs) detailing a strategy for meeting primary NAAQS. SIPs will include emission limits for existing sources necessary to maintain or bring the area into attainment with the NAAQS. The SIPs must also include provisions for implementing the Prevention and Significant Deterioration (PSD) program for attainment and unclassifiable areas, and visibility protection for certain pristine areas. Once EPA approves and SIP, it becomes federally enforeable.

On July 1, 1987, EPA issued revisions to the national ambient air quality standards (NAAQS) for particulate matter (52 FR 24634). The revisions included the following four key changes:

- Replaced total suspended particulates (TSP) as the indicator for particulate matter for the ambient standards with a new indicator that includes only those particles with a nominal aerodynamic diameter less than or equal to 10 micrometers (PM_{10});
- Replaced the 24-hour primary TSP standard of 260 $\mu g/m^3$ with a 24-hour PM_{10} standard of 150 $\mu g/m^3$ with no more than one expected exceedance per year;
- Replaced the annual primary TSP standard of 75 $\mu g/m^3$ with a PM_{10} standard of 50 $\mu g/m^3$, expected annual arithmetic mean; and
- Replaced the secondary TSP standard of 150 $\mu g/m^3$ with 24-hour and annual PM_{10} standards that are identical in all respects to the primary standards.

EPA recognizes the potentially large contribution of fugitive dust to total particulate matter in an area and created a fugitive dust policy in 1977 applicable to nonattainment areas for TSP. In this policy, EPA concluded that fugitive dust caused greater environmental impact in urban areas than in rural areas. EPA's lesser concern over TSP in rural areas is based on the following four factors: (1) the particulate matter consists of native soil which was believed to pose less of a health hazard than particles found in urban areas, (2) the population affected was small, (3) the economic base to support control was small, and (4) the cost of controlling miles of unpaved roads and acres of open land could be unreasonable. EPA's 1977 policy was that urban areas should receive the highest priority for development of programs for control of fugitive dust and programs in rural areas should focus on control of large existing manmade fugitive dust sources such as tailings piles and mining operations. In a notice on July 1, 1987 (52 FR 24716), EPA requested comments on three alternatives to the existing fugitive dust policy under consideration in response to the revised NAAQS. Until a revised policy is issued, EPA will continue to operate under the existing fugitive dust policy.

Any source with the potential to emit 250 tons per year or more of any air pollutant is considered a major emitting facility and is subject to the PSD program. Generally, one year of baseline air quality monitoring data is required before a PSD permit application is submitted. The application must demonstrate that emissions from the facility or modifications to a facility will not exceed the applicable increments or the NAAQS. The applicable increments are allowable increases in concentration of pollutants over a baseline concentration, but not to exceed the NAAQS.

Major stationary sources are required to apply the best available control technology (BACT) to pollutants that will be emitted in significant amounts [40 CFR 52.21(j)]. BACT may not be less stringent than new source performance standards (40 CFR Part 60) or National Emission Standards for Hazardous Air Pollutants (NESHAPs)(40 CFR Part 61). Specific emissions standards are set forth under NESHAPs for inorganic arsenic emissions from primary copper smelters (50 $\mu g/dscm$) and for radionuclide emissions from elemental phosphorus plants. The NESHAP controlling radionuclides from elemental phosphorus plants only addresses stack emissions, not slag or other potential radionuclide sources.

New source performance standards (NSPS) are emission limits that have been set by EPA to apply to new or modified sources which may contribute significantly to air pollution. NSPS requirements apply to individual operations within a facility. NSPS are not permit requirements, but they do require that performance tests be conducted (40 CFR 60.7-60.8).

7. Wetlands Protection

Section 404 of the Clean Water Act authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits, after notice and opportunity for public hearing, for the discharge of dredged or fill material into the waters of the United States at specified disposal sites. The phrase "waters of the United States" has broad meaning and is defined in 33 CFR 328.3 as follows:

- All waters used or that may be used "...in interstate and foreign commerce;"
- "All interstate waters and their tributaries, including interstate wetlands;"
- "All other waters such as intrastate lakes, rivers, streams including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce..." including any such waters used for recreational purposes, fishing, or industrial purposes by industries in interstate commerce;" and
- "All impoundments of waters otherwise defined as waters of the United States," including tributaries of waters defined above, the territorial seas, and wetlands adjacent to waters defined above.

Certain discharges of dredged and fill material into waters of the United States are permitted under the "nationwide permit" system as defined in 33 CFR 330. Nationwide permits are designed to allow certain activities to occur with little, if any, delay or paperwork and are valid only if the conditions applicable to the nationwide permits are met. Authorized activities are typically those which have minimal direct or cumulative environmental impacts (33 CFR 323.2(h)). Specific authorized activities are identified in 33 CFR 330.5 and include, among others, seismic survey activity; structures for the exploration, production, and transportation of oil, gas, and minerals on the outer continental shelf within leased areas; and bank stabilization activities. According to 33 CFR 323.3, individual 404 permits are required for any discharges to waters of the United States not covered by (1) the nationwide permit program, or (2) for discharges not requiring permits, such as those which might occur as a result of farming, silviculture, and ranching (33 CFR 323.4(a)). Mineral processing activities that involve discharges of dredged or fill material to waters of the United States may require individual 404 permits from the Corps if: (1) the activity is not covered by a nationwide permit and (2) the activity is not exempt from regulation.

The Corps of Engineers must review applications for Section 404 permits in accordance with guidelines promulgated by the EPA Administrator under authority of Section 404(b)(1) of the Clean Water Act. The Section 404(b)(1) guidelines specify that "no discharge of dredged or fill material shall be permitted which will cause or contribute to significant degradation of the waters of the United States" (40 CFR 230.10(c)).

8. Other Applicable Federal Laws

The laws discussed below are not all directly relevant to the mineral processing industry, but may be important for certain operations or in the overall consideration of environmental impacts.

The National Environmental Policy Act

Enacted in 1969, the National Environmental Policy Act (NEPA), 42 USC 4341, requires that,

> to the fullest extent possible, the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government

> shall include in every recommendation or report on...major Federal actions significantly affecting the quality of the human environment, a detailed statement...on (i) the environmental impact of the proposed action....

This requirement for preparation of an Environmental Impact Statement (EIS) establishes the framework and process by which EPA and the Council on Environmental Quality (CEQ) may impose the environmental protection requirements contained in all other federal environmental regulatory statutes on a wide variety of projects and activities. Environmental assessments must be prepared for any ore processing activities on federal lands, and similar activities that involve the use of facilities constructed with federal funds. EISs may be required for actions with significant impacts. CEQ regulations pertaining to the implementation of this law are found at 40 CFR Parts 1500-1508. EPA's corresponding regulations are found at 40 CFR 6. These requirements apply to Stauffer Chemical Company's elemental phosphorus facility in Silver Bow, Montana, Cyprus Mining Corporation's copper smelter in Claypool, Arizona, and Magma's copper smelter in San Manuel, Arizona, which are all located in National forests and Chevron Chemical Company's phosphoric acid plant in Rock Springs, Wyoming, which is on land owned by Bureau of Land Management, U.S. Department of Interior.

The Federal Land Policy and Management Act

The Federal Land Policy and Management Act of 1976 (FLPMA, 43 USC 1732, 1733, and 1782) authorizes the Bureau of Land Management (BLM) to regulate mining activities on its lands with respect to the environmental effects of such activities. Four of the facilities analyzed in this report are on lands owned by the federal government. The Bureau's regulations implementing this law (43 CFR 3809) are intended to prevent unnecessary or undue degradation of its lands, or lands that are under consideration for inclusion in the national wilderness system.

The regulations provide for reclamation of lands disturbed by mining and define three levels of mining operations. The first level, "casual use," applies to areas where mechanized earthmoving equipment and explosives are not used; a second level applies to surface disturbances of less than five acres per year; and a third level applies to disturbances of over five acres per year. For operations in the second level, operators must submit a letter or notice of intent; for operations on the third level, operators must submit a plan of operation that describes the proposed operation, including reclamation plans. Bonds are required when an operator has a record of noncompliance. These regulations apply to Chevron Chemical Company's phosphoric acid facility located in Rock Springs, Wyoming, which is situated on lands owned by BLM.

Forest Service Requirements

The Forest Service, U.S. Department of Agriculture, maintains regulations governing the use of the surface of National Forest System lands in connection with operations authorized by the United States mining laws. The regulations (36 CFR 228 Subpart A) are intended to "minimize adverse environmental impacts on National Forest system surface resources."

The regulations require that a "notice of intent to operate" be submitted by operators proposing to conduct prospecting or mining activities on Forest Service lands if the proposed activities might cause disturbance of surface resources. A proposed plan of operations is required if, in the judgment of the authorized Forest Service officer, operations would cause significant surface disturbance (e.g., if mechanized earthmoving equipment or explosives are to be used). All operations must minimize adverse environmental impacts to the extent feasible and must take into consideration federal, state, and local requirements concerning solid waste disposal and air and water quality. Consideration must also be given to the reclamation of disturbed lands. Reclamation bonds may be required by the authorized officer. These regulations also apply to the Stauffer Chemical Company plant in Silver Bow, Montana, and the Cyprus Mining Corporation's smelter in Claypool, Arizona, and Magma's copper smelter in San Manuel, Arizona.

Appendix D-2

Existing Regulatory Controls Addressing Mineral Processing Wastes in Selected States

Appendix D-2
Existing Regulatory Controls Addressing Mineral Processing Wastes in Selected States

EPA's goal in the analysis of state regulatory programs was to determine the current state regulatory status of the mineral processing wastes generated by the twelve commodity sectors addressed in the Report to Congress. The "State Regulation" section of each chapter (X.4.2) summarizes the findings of this analysis. This appendix presents the more detailed information upon which EPA based its review of and conclusions regarding state waste regulatory programs.

The analysis of state regulatory programs consisted of three steps. The first step focused on reviewing material in a report on state-level regulation of mining and mineral processing wastes ("CDM report").[1] The second step was to perform a more detailed review of individual state statutes and regulations. This step included the selection of a subset of states for further study. The final step in the analysis involved contacting state officials in the eighteen study states to clarify state regulations and obtain facility-specific information where possible. The three steps of the state regulatory analysis are summarized below.

First, EPA examined the material in the CDM report that pertains to all 29 states with one or more facilities considered in the Report to Congress, and summarized portions of the hazardous waste, solid waste, air quality, and water quality statutes and regulations that are relevant to the current disposition of the special study wastes. Although the CDM report provides a general overview of state statutory and regulatory requirements addressing wastes from the extraction, beneficiation, and processing of ores and minerals in all 50 states, it was not designed to provide the detailed analysis of the scope, and in particular, the implementation of regulations that address mineral processing wastes, that EPA believes is necessary for the Report to Congress.

The second step of EPA's analysis, therefore, was designed to provide more detailed information on the scope and implementation of mineral processing wastes. Time and resource constraints made it impossible to perform a detailed regulatory analysis on all of the states that contain facilities that generate a special mineral processing waste. Consequently, this step in the analysis involved selecting a representative sample of the 29 states for further analysis, in order to balance the need for comprehensive coverage of the mineral commodity sectors with the need to work with a manageable number of states.

To select a subset of states, EPA employed the following criteria: (1) the percentage of facilities in each state and in each sector covered by the regulatory analysis; and (2) the percentage of total waste volume generated by each waste stream and sector covered by the regulatory analysis. Exhibit D-2-1 of this appendix demonstrates the high percentage of facilities and total waste volume represented by the eighteen states chosen for further study, while Exhibit D-2-2 illustrates the location of these 19 study states.

Although this second step resulted in a detailed analysis of the statutes, regulations, and other information for each of the eighteen selected states, EPA found that the scope of state programs was not always made clear by the states' statutory and regulatory language. The final step of the analysis, therefore, consisted of calling state officials in order to learn how those statutes and regulations are interpreted in practice, and to obtain facility-specific implementation information where possible. The information compiled from these contacts was combined with the existing information on statutory and regulatory requirements to produce a final implementation analysis, which reviews the existing regulatory structure applicable to the 20 mineral processing wastes generated by the twelve commodity sectors considered in this Report to Congress.

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[1] Camp, Dresser, and McKee Federal Programs Corporation (CDM). State Regulation of Solid Wastes from the Extraction, Beneficiation, and Processing of Non-Fuel Ores and Minerals, June 2, 1989. Prepared for U.S. Environmental Protection Agency, Office of Solid Waste; Document Control Number: T1142-ROO-DR-DELC-1.

Exhibit D-2-1
Summary of Results of Selection Criteria Evaluation

Sector	Total Number of Facilities	Number of Facilities in Study States	Percent of Facilities in Study States	Percent Waste Volume Generated in Study States	Notes on Volume Data(a)
Alumina	5	4	80	93	
Chromate	2	2	100	NA(b)	2 of 2 facilities CBI
Coal Gasification	1	1	100	100	
Copper	10	9	90	90	3 of 10 facilities CBI
Elemental Phosphorus	5	5	100	NA(b)	3 of 5 facilities CBI
Ferrous Metals	28	19	68	80	2 of 28 facilities CBI
Hydrofluoric Acid	3	3	100	100	1 facility NR(c)
Lead	5	4	80	NA(b)	3 of 5 facilities CBI
Magnesium	1	1	100	100	
Phosphoric Acid	21	20	95	100	2 of 21 facilities CBI
Titanium	9	5	56	NA(b)	8 of 9 facilities CBI
Zinc	1	1	100	100	

(a) CBI = Confidential Business Information
(b) NA = Insufficient data to calculate accurately due to Confidential Business Information (CBI) status
(c) A single hydrofluoric acid facility owned by duPont did not submit a survey response

The complete findings of this analysis have been included on a state-by-state basis in the remainder of this appendix.

Arizona

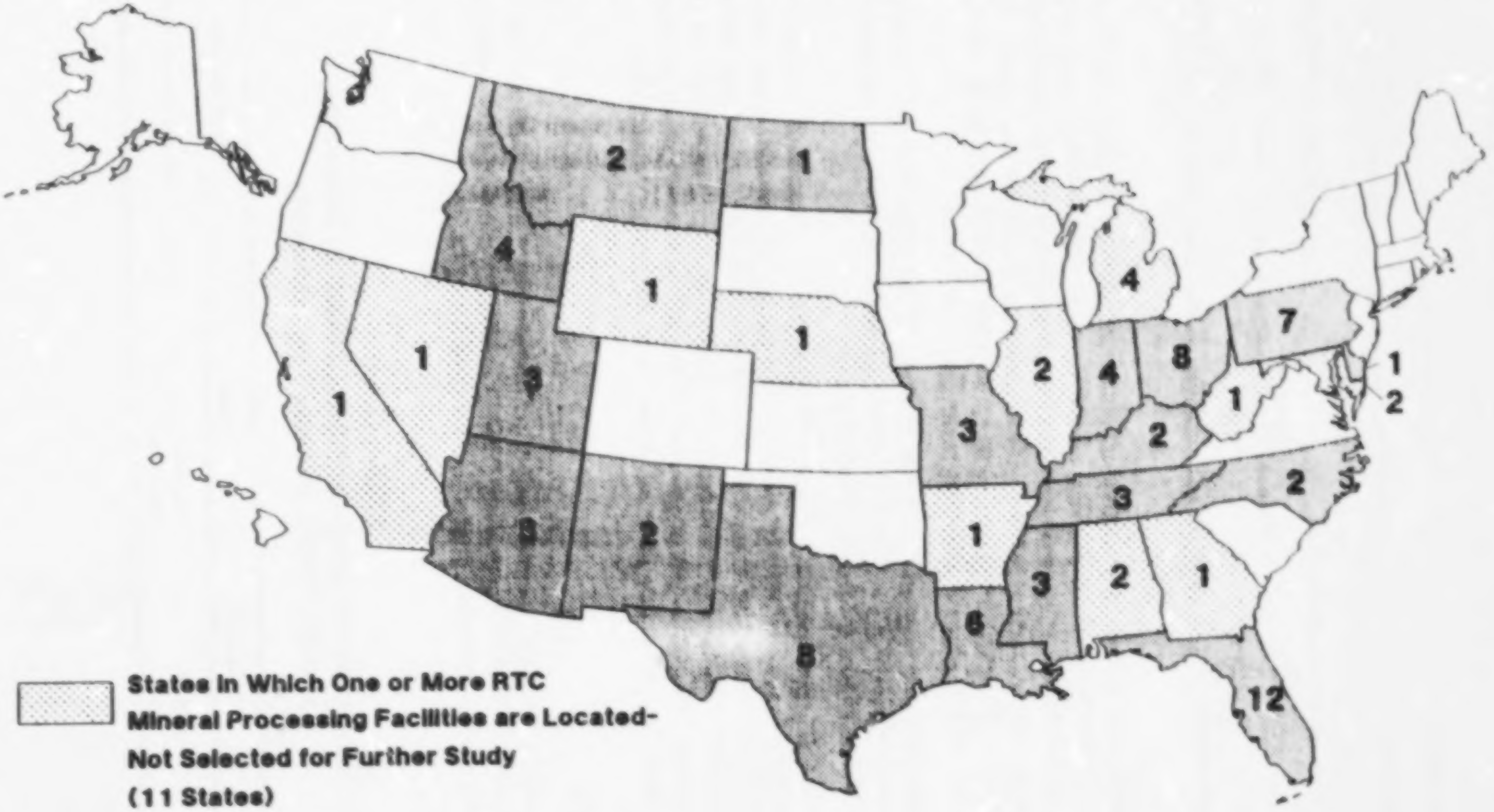
There are three copper processing facilities in Arizona under study for this report. The facilities, their locations, and the waste streams they generate are presented in Exhibit D-2-3. All three generate furnace slag, while only the facility in Hayden generates calcium sulfate sludge, and only the facility in San Manuel generates slag tailings.

Arizona adopts the Federal exemption from hazardous waste regulation for wastes from the extraction, beneficiation, and processing of ores and minerals. Arizona's Solid Waste Management Law and Solid Waste Rules include coverage for industrial wastes. According to State officials, however, the State's emphasis in implementing its regulations has been on municipal solid waste, especially with regard to the siting and construction of solid waste landfills. The State has not imposed regulations specifically regulating wastes from mining and mineral processing operations.

The implementation of Arizona's water quality control statutes and regulations affects mineral processing wastes more directly. As part of the State's initial ground-water protection efforts, all existing dischargers were required to submit notices of disposal. The State established priorities through the evaluation of these notices and proceeded to address them in order through its new Aquifer Protection Program. According to State officials, they are behind schedule in permitting the numerous facilities. Permit requirements are based on the Best Available Demonstrated Control Technology (BADCT). Permit

Exhibit D-2-2

Distribution of States Selected For Further Statutory and Regulatory Analysis for the Mineral Processing Wastes Report to Congress



░ States in Which One or More RTC Mineral Processing Facilities are Located-Not Selected for Further Study (11 States)

▨ States in Which One or More RTC Mineral Processing Facilities are Located-Selected for Further Statutory and Regulatory Analysis (18 States)

* The number in each state indicates the number of RTC mineral processing facilities located in the state.

Exhibit D-2-3
Mineral Processing Facilities Located in Arizona and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
ASARCO	Hayden	Copper	1. Slag 2. Calcium Sulfate Sludge
Cyprus	Claypool	Copper	1. Slag
Magma	San Manuel	Copper	1. Slag 2. Slag Tailings

requirements include liners and prescribed procedures for liner installation, consideration of treatment before discharge or disposal, and monitoring of all kinds, including ground-water monitoring and double liner leak detection. Surface impoundments, including holding impoundments, storage settling impoundments, treatment or disposal pits, ponds, lagoons, and mine tailings piles or ponds are specifically listed as discharging facilities that must be permitted. The State has inspection and enforcement authority through the Aquifer Protection Program and has utilized both of those authorities in the past.

The Arizona Rules and Regulations for Air Pollution Control adopt Federal new source and existing source performance standards for primary copper smelting operations. In addition, the regulations include fugitive dust limitation conditions for tailings piles and ponds.

The Hayden facility does not have an aquifer protection permit. The facility in Claypool received an aquifer protection permit in October 1989 for a tailings reprocessing unit; however, other operations at the facility, including hydraulic remining of old waste piles, are not currently subject to permit requirements. The facility in San Manuel has an aquifer protection permit for its heap leaching operation, but not for its tailings pond. According to State officials, the lack of permits at these facilities is attributed to the emphasis put on permitting new facilities, and to the long list of existing facilities that need to be permitted.

Delaware

There is only one mineral processing facility in Delaware that is under study for this report. The single facility is a titanium tetrachloride processing facility that generates chloride process waste solids. That facility, its location, and the waste stream it generates are presented in Exhibit D-2-4.

Exhibit D-2-4
Mineral Processing Facilities Located in Delaware and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
duPont	Edgemoor	Titanium Tetrachloride	1. Chloride Process Waste Solids

The Delaware Hazardous Waste Management Regulations specifically exclude wastes from the extraction, beneficiation, and processing of ores and minerals from regulation as hazardous waste. Therefore, chloride process waste solids from titanium dioxide production are not regulated as hazardous waste in Delaware.

The Solid Waste Disposal Regulations include in their definition of industrial waste, any substance resulting from the operation of or from any process of industry, manufacturing, trade, or business, or from the development of any natural resource. The regulations list specific design standards for on-site industrial landfills that include: analysis of the chemical and physical properties of the industrial waste; plans for leachate collection, treatment, and disposal systems; hydrological reports, including test borings to determine the soil and ground-water conditions; methods for venting and monitoring gases within the landfill; liners; and setback areas. Sanitary landfills have separate design and operating standards, most of which mirror those that apply to industrial landfills. One difference is the use of a toxicity test that must be applied to any non-municipal waste that is to be disposed in a municipal landfill. Industrial landfill permits specify which wastes can be accepted. Sanitary landfills, in contrast, tend to receive many different types of wastes; the toxicity test serves as a means of preventing hazardous wastes from being disposed of in these landfills. A new set of solid waste regulations was enacted in December 1989, and all the existing industrial landfills are in the process of coming under these requirements.

At present, all solid waste disposal facilities are required to submit either annual or quarterly reports assessing their compliance with their landfill permits. They also are required to submit closure plans that must include provisions for landfill capping, gas control, surface water run-off control, ground-water monitoring, and 30-year post-closure care. Although the State can and does conduct on-site inspections, it can only revoke a permit and deliver a cease action order. It cannot force remediation activities on the part of the facility.

Inactive or abandoned sites are sometimes passed over to the solid waste division from the State Superfund division. There are no official regulations concerning how the solid waste division must deal with these sites. The State is presently working under the authority of a policy paper that requires the present owner of the property to totally remove all pollutants from the site. There have been some legal challenges to this policy paper, but the State has been successful in the majority of the cases.

Delaware does have an approved NPDES program and continues to issue discharge permits for all point source discharges in the State. Permits for industrial wastewater discharges must require treatment that reflects, at a minimum, a practicable level of pollutant removal technology. Management practices required in the permits include specifications for monitoring of effluent levels and operating practices for the permitted facilities.

The titanium tetrachloride facility in Delaware under study for this report is the duPont facility in Edgemoor, DE. It currently generates chloride process waste solids, which are treated and landfilled. There is a surface impoundment on-site where the solids are co-managed with other wastes from the process. Initially, the facility had a solid waste permit for the on-site surface impoundment and for the process of allowing the chloride process waste solids to settle out to be eventually dredged and landfilled at another location. This landfill is on Cherry Island and is permitted separately as an industrial landfill. It is not clear from speaking with State officials whether the Cherry Island landfill is situated on land that is owned by the duPont company. The solid waste permit for the on-site impoundment was transferred to the Delaware Water Resources Division in early 1990, as were all surface impoundment permits currently in existence in the State. The Water Resources Division of the Delaware Department of Natural Resources and Environmental Conservation has yet to address the existing permit situation and has instructed duPont to continue operating under the terms of the solid waste permit until further notice. duPont also obtained a NPDES permit, which expires in September 1994, to discharge from the on-site surface impoundment. Requirements of the permit, in addition to the regimen of effluent monitoring from the four outfalls, include bio-monitoring procedures.

Florida

As shown in Exhibit D-2-5, there are 12 phosphoric acid facilities in Florida that are under study for this report. All 12 facilities produce both phosphogypsum and process wastewater.

Exhibit D-2-5
Mineral Processing Facilities Located in Florida and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Agrico	Mulberry	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Central Phosphate	Plant City	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
CF Chemicals	Bartow	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Conserv, Inc.	Nichols	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Farmland Ind.	Bartow	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Gardinier, Inc.	Riverview	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
IMC Fertilizer	Mulberry	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Royster	Mulberry	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Royster	Palmetto	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Seminole Fertilizer	Bartow	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
US Agri-Chem	Ft. Meade	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Occidental Chemical	White Springs	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum

The Florida Hazardous Waste Rules exclude "discarded material generated by the mining and chemical or thermal processing of phosphate rock and precipitates resulting from neutralization of phosphate chemical plant process and nonprocess waters" from regulation as hazardous waste. The rules incorporate by reference the Federal identification of hazardous waste, including the exemption for wastes from extraction, beneficiation, and processing of ores and minerals.

The Florida Solid Waste Disposal Facilities Regulations do not contain specific requirements pertaining to phosphogypsum stacks, though the State is currently drafting regulations to address them. The solid waste rules prohibit disposal except by sanitary landfill, incineration, recycling process, or "other approved method" consistent with the requirements of the rules. In the absence of express guidelines for stacks, the State has adopted modified landfill requirements, when appropriate, for regulation of phosphogypsum stacks. After considering ground-water monitoring data from facilities without liners under the stacks and from one facility with a stack liner, the Department of Environmental Regulation required liners for all new stacks and expansions of old stacks.

According to State officials, phosphoric acid facilities may have two types of permits for their solid waste disposal activities. Typically, old stacks have an Industrial Wastewater Discharge Permit. Under the 1988 Solid Waste Management Act, new facilities are required to obtain a solid waste disposal permit. Some facilities may have both. Specific requirements for each facility are contained in the solid waste permit. The rules delineate site restrictions for solid waste disposal facilities (e.g., no disposal in an area subject to frequent and periodic flooding). Requirements in solid waste disposal permits may address location, performance standards (e.g., liner requirements), and operations (e.g., ground-water monitoring). Florida is currently in the process of developing operating and construction standards for stacks. There are no closure requirements for any of the units.

Currently, the existing cooling ponds for wastewater are not required to be lined. According to State officials, this will be addressed in the new regulations.

State officials have indicated that the Department has authority for on-site inspections and enforcement authority to issue administrative and consent orders. They do not, however, have authority to fine facilities for non-compliance. The Department must bring a facility operator to court to sue for damages. The mechanism for ground water cleanup is a CAPRAP or "contamination assessment report and remedial action plan."

Florida does not have an EPA-approved NPDES program. The Florida Wastewater Facilities Regulations incorporate by reference Federal "Effluent Guidelines and Standards for Mineral Mining and Processing" (40 CFR 436). The regulations contain standards (Title 17-6.310) that are more stringent than the Federal Guidelines. According to the State official, however, these regulations apply to mining of phosphate ore and not to processing. The cooling ponds associated with the phosphogypsum stacks are required to adhere to the design and operating standards for earthen dams in Title 17-9.

Because of ongoing modification to the solid waste regulations with regard to design and operating standards specific to phosphogypsum stacks and cooling ponds, the State official noted that the interim policy is to require any new or expansion of existing stacks or ponds to be lined and undergo formal closure. Under this policy, closure requirements include adequate cover to prevent infiltration, and run-off controls. The State may require remedial action by the owner/operator, which could be in the form of slurry walls or a ground-water recovery system.

According to the State official, all the ponds have run-on/run-off controls. The State has adopted the Federal Guidelines, which require controls to manage the storm water from a 25 year, 24 hour storm. Ground-water monitoring around the stacks also is required. According to the State official, the new stacks and ponds rarely need to discharge because of their huge capacity. All the phosphogypsum stacks and ponds, however, do have Federal NPDES permits in case there is a need to discharge to surface waters.

The State official related that the typical facility is comprised of a mine and an associated chemical plant. The mine will have its own Industrial Waste Permit, and the chemical plant also will have an Industrial Waste Permit. Therefore, a facility typically has 2 permits for disposal, each addressing its own discharge. An entire facility, however, typically only has one NPDES permit.

Under the Florida Air Pollution Rules, emissions from the phosphate industry are regulated. Rules exist for wet phosphoric acid production. According to a State official, phosphogypsum stacks and cooling ponds are not expressly mentioned in air permits. The basic concerns from these systems are fugitive dust and radon emissions. According to the State official, the stacks tend to "heal over," or crust. Fugitive dust and radon, therefore, have not historically been a concern for the air program. The State official related that the stacks are part of a wet system, which also helps to control potential dust emissions. Nonetheless, the operator of the Gardinier facility covered its old phosphogypsum stack with grass at closure in order to control future particulate emissions. This was, however, in response to a local rather than a State requirement.

Idaho

There are two phosphoric acid facilities and two elemental phosphorus facilities in Idaho that are under study for this report. The facilities, their locations and the waste streams they generate are presented in Exhibit D-2-6.

Exhibit D-2-6
Mineral Processing Facilities Located in Idaho and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Monsanto	Soda Springs	Elemental Phosphorus	1. Slag
FMC Corporation	Pocatello	Elemental Phosphorus	1. Slag
J.R. Simplot	Pocatello	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Nu-West Industries	Soda Springs	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum

Under the Idaho Hazardous Waste Management Regulations, "solid waste from the extraction, beneficiation, and processing of ores and minerals, including coal, phosphate rock, and overburden from the mining or uranium ore" are exempt from regulation as hazardous waste.

According to State officials, phosphogypsum and process wastewater from phosphoric acid production are subject to neither the Idaho Solid Waste Law, nor the Idaho Solid Waste Management Regulations. No solid waste permits are required for disposal of mineral processing wastes. Idaho does ban the use of elemental phosphorus slag as construction material in habitable structures.

Idaho does not have a Federally-approved NPDES program. The Idaho Water Quality Standards and Wastewater Treatment Requirements regulate the State's waters based upon water use classifications. Non-sewage discharges must be treated to the extent necessary to ensure compliance with Sections 301 and 304 of the Federal Water Pollution Control Act.

Particulate matter emission limitations applicable to any process are given in the Air Pollution Control Regulations. According to State officials, the air permits do not contain specific requirements regarding phosphogypsum stacks, cooling ponds, and slag piles. The Simplot and Nu-West facilities are broadly responsible for "reasonable control of fugitives," but there is no express mention of stacks or ponds in the air permit.

Indiana

Four facilities generate special wastes from mineral processing in Indiana. Each of these facilities is a fully integrated ferrous facility generating iron and basic oxygen furnace steel slag and air pollution control dust and sludge. Exhibit D-2-7 shows the names and locations of the four ferrous facilities in Indiana.

Ferrous wastes (iron and steel slag and iron and steel air pollution control dust and sludge) are the only special wastes from the processing of ores and minerals generated in Indiana.

The Indiana Solid Waste Management Permit Regulations exempt from regulation:

> (13) The legitimate use of iron and steelmaking slags including the use as a base for road building, but not including land reclamation except as allowed under subdivision (15)...

Exhibit D-2-7
Mineral Processing Facilities Located in Indiana and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Bethlehem Steel	Burns Harbor, IN	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Slag 4. Basic Oxygen APC Dust/Sludge
Inland Steel	E. Chicago, IN	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Slag 4. Basic Oxygen APC Dust/Sludge
LTV Steel	Indiana Harbor, IN	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Slag 4. Basic Oxygen APC Dust/Sludge
US Steel	Gary, IN	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Slag 4. Basic Oxygen APC Dust/Sludge

> (15) Other uses of solid waste may be approved by the commissioner if the commissioner determines them to be legitimate uses that do not pose a threat to public health and the environment (329 IAC 2-3-1).

State officials noted that, although this means that iron and steel slag may not be subject to regulation in a number of cases, this provision is interpreted cautiously and land reclamation or any use of slag would only be allowed with proof that no contamination of the environment could result.

APC dust and sludge is considered a special waste by the State of Indiana and may be only disposed off-site in one of twelve landfills designated to accept special waste, or in other landfills as determined on a case-by-case basis. Requests for disposal of special waste are matched by the State with a landfill or disposal site approved by the State. Generators generally indicate the landfills in which they would like approval to dispose of special waste. The EP toxicity test and the neutral water leaching test are used to determine the degree of hazard a waste may pose, and are part of an extensive application submitted to the State in order to determine suitable sites for disposal. Sites previously approved for solid waste disposal will be reviewed by the State under the authority of the proposed rule. Another provision of the proposed rule will require the State to issue certifications of special waste status to industry. The certifications will provide generators with a permit to dispose of waste at a landfill of their choice. Although the details of this provision are not established, industry could have a greater opportunity to select the most competitively priced waste management facility for disposal of special waste.

On-site disposal of APC dust and sludge, a practice used by both Inland and US Steel, was informally exempt from these requirements until February 1989, when a new rule regulating residuals went into effect. Although disposal of dust and sludge was informally monitored by State inspectors, facilities were not required to meet the standards of special waste landfills.

The new rule gave facilities until September of 1989 to file a notification to the State including basic information on the industrial process undertaken at the facility, what wastes were generated, including any available waste characterization data, and how the waste was managed at that time. After reviewing this material, State officials will conduct further waste characterization sampling and determine either 1) what types of off-site landfills these wastes may be hauled to, or 2) what type of restricted waste landfill permit these facilities would have to apply for. Permits for these facilities will be called in on a schedule. By April 1990, three of the four iron and steel facilities in Indiana had filed the required notification.

Following determination of what type of site may accept the wastes as described in the facility notifications, sites must either meet the new requirements or close. Restricted sites will range from sanitary landfills, which must have ground-water monitoring wells, ten feet of clay barrier or a synthetic liner, and extensive evaluation by State officials, to the least restrictive landfill that may not even be required to have monitoring wells.

Existing sites that were required to close could, in the most stringent scenario, be required to be covered with two feet of clay and six inches of topsoil and vegetation, grade to a minimum slope and meet certain erosion control requirements through the placement of inert materials, in order to prevent pooling; establish monitoring wells; and possibly undertake a post-closure period of ten years that would include biannual ground-water monitoring, inspection and maintenance of cover, and financial assurance. Rule 9 of the regulation includes requirements on determining the type of waste to be disposed of; Rule 10 includes minimum design standards. State officials cautioned, however, that none of the waste management operations at any of the facilities had been classified at this time, and it was not possible to estimate exactly what requirements each facility would have to meet.

Waste management requirements under the new rule will be determined on a case-by-case basis, under the assumption that each material is somewhat different. Although the State may take enforcement action and exercise corrective action authority at any time when there is an imminent threat to human health and the environment, State officials were not able to estimate when waste management requirements established under the new rule would be established for each facility. Financial penalties of up to $25,000 a day per violation are possible; the State is presently working on a penalty matrix.

In the case of inactive and abandoned sites, the State may require cover and leachate abatement activities, depending upon a determination of the potential threat to human health and the environment.

Requirements for ground-water controls vary by facility and by facility NPDES permit. A substantial amount of run-off from Bethlehem Steel may go to a lagoon system, although for the most part, slag piles are unlikely to be required to have run-off controls, according to a State official. Bethlehem is apparently built on a sandy base that prevents a substantial amount of run-off. The Inland and Armco facilities in Indiana, however, are required to have run-off controls for their slag disposal or management sites through the facilities' NPDES permits. Although most of the cooling water at US Steel is recirculated, some is blown-down, and excess is discharged with rain run-off from the slag piles. State officials indicated that circulating water at Inland dust and sludge impoundments is re-used and has been examined and demonstrated to pose no threat of water contamination.

Although the four primary steel mills in Indiana are required to submit fugitive dust program plans to the State, according to State officials, these plans have not been approved or disapproved. Steel mills must in general employ fugitive dust controls. The State, however, lacks extensive authority to require controls. The State has much more leverage when issuing construction permits to include air quality requirements, such as fugitive dust controls, than when issuing and re-issuing operating permits. To a large extent, local agencies have the primary responsibility for establishing requirements, extracting commitments to control emissions, and issuing permits. Thus, commitments to use dust suppression measures may be somewhat informal which makes any legal enforcement by the State difficult. In addition, facilities are then not bound by any enforceable requirement to continue air emission control measures under less than ideal conditions such as inclement weather or problems with vendors of dust suppression equipment.

Requirements for air quality control have been formally and informally arranged with the Bethlehem facility in Burns Harbor, and formally established through rulemaking for the US Steel facility in Gary. Most requirements for control of particulate matter emissions are established through rulemakings that specify requirements for a facility by name.

The steel industry and the State differ on whether it is the responsibility of the steel mills or the slag processors regarding dust suppression measures on slag that is to be re-processed. Certain slag processors have submitted dust suppression plans, though the State does not have the authority to require these plans, to approve or disapprove plans, or to establish specific requirements. The State hopes to gain more significant regulatory control over the numerous slag processors operating at the site of the four primary steel mills.

Kentucky

Two facilities generate special wastes from mineral processing in Kentucky. One facility is a fully integrated ferrous facility generating iron and basic oxygen furnace steel slag and air pollution control dust. The other facility generates process wastewater and fluorogypsum from hydrofluoric acid production. Exhibit D-2-8 shows the names and locations of the two mineral processing facilities in Kentucky.

Exhibit D-2-8
Mineral Processing Facilities Located in Kentucky and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Armco, Inc.	Ashland	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge
Atochem (Pennwalt)	Calvert City	Hydrofluoric Acid	1. Fluorogypsum 2. Process Wastewater

Two facilities in Kentucky generate wastes from the processing of ores and minerals. Armco generates ferrous wastes, and Atochem generates fluorogypsum and process wastewater from hydrofluoric acid production.

Mineral processing wastes are not subject to hazardous waste regulation in Kentucky. Certain solid waste management, water, and air regulations, as well as provisions in a proposed residuals rule, apply to ferrous wastes and hydrofluoric acid wastes similarly. To a large extent, however, these wastes are regulated on a site-specific basis.

Landfilling of solids is permitted under existing solid waste regulations. Kentucky officials have the authority to conduct inspections and enforcement activities, and to impose penalties for violations. Solid waste management facilities are required to have financial assurance for closure. Both ferrous wastes and hydrofluoric acid wastes may be regulated more strictly after the implementation of a residuals rule, which may be effective as early as the middle of July 1990. Landfills may be required to conduct additional ground-water monitoring and undertake formal closure activities under the requirements of the proposed residuals rule. In addition, the rule includes restrictions on the transportation of waste. Despite these general requirements, ferrous wastes and hydrofluoric acid wastes are primarily regulated on a site-specific basis.

Iron and steel slag and iron and steel air pollution control dust are managed separately and thus regulated differently in Kentucky. According to one State official and the Armco response to the SWMPF Survey, 100 percent of BF slag generated by the Armco facility in Ashland is sold to a processor (Heckett Co.) and 90 percent of steel slag is sold for processing, with the remaining ten percent returned to the sinter plant. According to another State official, slag which is not re-processed or otherwise used is disposed of in one of the two inert landfills Armco maintains on-site. These landfills are required to manage waste in an environmentally protective manner by employing and maintaining a monthly cover, operating according to a plan and permit, and using run-on and run-off controls and drainage ditches. Although State officials noted that there have been problems in the past with leaching of contaminants from slag use, the use of slag is not subject to regulation. If it is demonstrated that leaching has occurred because of the use of iron or steel slag, the facility could be cited, and enforcement through the waste management or water divisions could follow.

Regulation of air pollution control dust and sludge is somewhat more strict. The Armco facility disposes dust and sludge off-site at a residential landfill in Boyd County. Residential landfills are subject to requirements for ground-water monitoring.

The Atochem, Calvert City facility operates the only permitted "hydraulic landfill" (i.e., the facility's surface impoundment) in the State. The landfill is not designed to discharge to ground or surface water. Ground-water monitoring wells are located around the landfill (fluorogypsum pond) in accordance with the existing solid waste regulations. The fluorogypsum disposal site will be, after the promulgation of the proposed rule, regulated as a residual landfill. When renewing its solid waste permit, the facility will be required to obtain a permit for a residual landfill, continue to show that the waste is non-hazardous, and possibly upgrade the present ground-water monitoring operations. State officials noted that the material has a low permeability and that there is little possibility for contaminant transport. Even if there were no attenuation of contaminants, however, leachate would still not exceed point-source discharge limits, according to State officials.

State officials added that a CERCLA workforce is evaluating all closed landfills that were allowed to operate without permits, and that this investigation includes two sites at the Calvert City facility.

Water protection requirements in Kentucky apply similarly to both Armco and Atochem, although hydrofluoric acid process wastewater is the only waste stream subject to specific controls. At this time, the Atochem facility has a NPDES permit for discharge of process wastewater (State officials believe, however, that 100 percent of hydrofluoric acid process wastewater is recycled at the Atochem facility). Dikes located around the fluorogypsum pond provide some run-off control.

In order to obtain a NPDES permit, the hydrofluoric acid process wastewater or any iron and steel plant discharges must be characterized, and this information must be submitted to the State. The permit application also must include the flow rate, how much effluent is discharged, the mixing zone of the effluent, the size of the stream to which effluent will be discharged, the pH, and the concentration of suspended solids.

Permitted facilities operate under a self-monitoring system and must submit reports on effluent on a periodic basis, ranging from several times daily to monthly. Each facility has an average and maximum value it must achieve. Permits are in effect for five years unless a facility undergoes modification. Permits are drafted by the Kentucky ground-water branch and then subject to a 30 day public comment period. After final review and modification, permits are issued in final form.

The Atochem facility must meet standards for stormwater run-off from its operating and closed fluorogypsum ponds. Similarly, it is likely that Armco must meet standards for stormwater run-off from any slag piles or APC dust and sludge waste piles or surface impoundments. Kentucky officials monitor surface water discharges and impacts to ground water. The facility must divert stormwater to prevent contamination of ground or surface water and monitor these discharges for hazardous characteristics using a chemical measuring device. Some facilities, including the Atochem and Armco, may also do toxicity testing using aquatic organisms; this test would apply mainly to process wastewaters. The Atochem facility recently renewed its permit, which includes human health and aquatic life discharge limits.

The nature of the ferrous wastes results in stricter fugitive dust requirements for the Armco facility than for management of the predominantly liquid hydrofluoric acid wastes at the Atochem facility. Facilities such as Atochem must meet general requirements regarding fugitive dust. Requirements are based on visual observation and rely on the discretion of the inspector, according to State officials. The Calvert City facility has certain fluorospar kilns and waste piles that it may be required to revegetate, although State officials were not aware of any fugitive dust problems at the facility. As stated above, the nature of fluorogypsum as currently managed effectively precludes any fugitive dust problems.

Strict air pollution controls are employed at the Armco facility to prevent fugitive dust emissions. At the time when slag is tapped from the blast furnaces, the molten slag is hit with "big sprays." The slag is dumped into a two and one-half ton end loader, which then goes through a truck watering station where the slag is "quenched." The trucks then travel along an oiled road surface (another dust suppression mechanism) to the Heckett processing facility. A controlled precipitator captures dust from each of the basic oxygen furnaces, which is then hauled in covered trucks to a private landfill. Blast furnace air pollution control waste is eventually hauled to the same landfill, yet is apparently generated as a sludge which is hauled to ponds and then loaded into trucks. Kentucky air officials have the authority to inspect the Armco facility and do so on a regular basis.

Louisiana

In Louisiana, there are two alumina facilties, one hydrofluoric acid facility, and three phosphoric acid facilities, as shown in Exhibit D-2-9.

Exhibit D-2-9
Mineral Processing Facilities Located in Louisiana and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Agrico	Donaldson	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Agrico	Uncle Sam	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Arcadian	Geismar	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum
Kaiser	Gramercy	Bauxite	1. Red and Brown Muds
ORMET	Burnside	Bauxite	1. Red and Brown Muds
Allied-Signal	Geismar	Hydrofluoric Acid	1. Process Wastewater 2. Phosphogypsum

The Louisiana Hazardous Waste Management Regulations exclude "solid waste from the extraction, beneficiation, and processing of ores and minerals, including coal, phosphate rock, bauxite, and overburden from the mining of uranium ore" from regulation as hazardous waste.

In Louisiana, phosphogypsum and process wastewater from phosphoric acid production, fluorogypsum and process wastewater from hydrofluoric acid, and red muds from alumina production are considered industrial wastes and are subject to the requirements of the Louisiana Solid Waste Management and Resource Recovery Law and the Louisiana Solid Waste Regulations. The regulations outline general site requirements for all solid waste disposal facilities, including provisions for soils (e.g., stability, low permeability), hydrological characteristics, locational characteristics (e.g., proximity to critical environmental areas), security, safety, and monitoring of incoming wastes.

According to a State official, there are no express requirements in the regulations for phosphogypsum stacks or fluorogypsum stacks. Instead, they are subject to the majority of the industrial solid waste landfill requirements of the solid waste regulations. The stacks are not required to adhere to the daily cover requirements for landfills. Phosphogypsum stacks are required to have controls that contain run-off from operating areas. According to a State official, liners are required for new impoundments and stacks; "new" applies to facilities built after July, 1983. During closure, the owner or operator is required to emplace either a final cover or alternative erosion control measures if installation of a final cover is infeasible. The owners/operators must meet financial responsibility requirements for closure and post-closure care.

The impoundments that receive the process wastewaters and red muds must adhere to specific requirements for surface impoundments outlined in the regulations. Under these requirements, owners or operators must ensure that each surface impoundment has the following: controls so that surface run-on will be prevented from entering the facility; an artificial or natural liner on the bottom and sides of the impoundment which is equivalent to three feet of clay with the coefficient of permeability of $1x10^{-7}$ cm/sec for ground-water protection; design and operation standards that prevent overtopping by overfilling, wave action, or storms; a perimeter levee to minimize wind and water erosion; and weekly inspections. Ground-water monitoring around the impoundments is required. For surface impoundments, samples must be analyzed for total dissolved solids, plus three other parameters intrinsic to the waste source. The liner requirement applies to "new" surface impoundments (i.e., those built after July, 1983).

Closure and post-closure care requirements for surface impoundments also are addressed in the regulations. The impoundments must be dewatered. If the remaining solids are removed, no other closure or post-closure care requirements apply. If solids remain in the impoundment, owners/operators must adhere to the closure and post-closure requirements for industrial solid waste landfills. Owners/operators must meet financial responsibility requirements for closure and post-closure care of surface impoundments.

Permits are required in order to construct a new facility or make major modifications to an existing facility. An interim permit may be issued to the operator of an existing facility (any facility collecting or receiving solid waste and not closed prior to January 20, 1981) while an application is being processed, or while a facility or site is being modified. According to the State official, the permit application, after review, essentially becomes the permit. If the Department disagrees with something in the application, the Department attaches conditions to the application that must be met. The Arcadian facility and the two Agrico facilities that produce phosphoric acid, the Allied Signal hydrofluoric acid facility, and both the Kaiser and ORMET alumina facilities have "standard permits," which means each facility has fulfilled all of its permitting obligations and met all the requirements of the regulations. According to the State official, the ORMET facility has a standard permit for its red mud lake and two red mud impoundments are being closed. The State official explained that when the Department of Environmental Quality considers bringing a facility into the program, it has two options for a unit, including upgrade or closure. If the State determines that it is not worthwhile to upgrade units, these units typically are closed.

The Department has on-site inspection authority. The authority for administrative and enforcement activity is outlined in the Environmental Quality Act, Sections 212 and 225. The Department can issue consent orders, administrative orders, and notices of violation, depending on the nature of the problem. As an example, the State official noted that if the Department notices an activity it wants changed, even if that activity does not necessarily constitute a violation, it may issue a consent order.

Because Louisiana does not have an EPA-approved NPDES program, Federal NPDES permits are required for surface water discharges. All three phosphoric acid facilities in Louisiana have NPDES permits. The Allied-Signal facility discharges to the Mississippi River through permitted NPDES outfalls. In addition, under the Louisiana Water Pollution Control Regulations, a permit from the State is required in order to discharge leachate or run-off to surface waters from facilities. Permits are administered through the Louisiana Water Discharge Permit System.

The Louisiana Air Pollution Control Regulations (LAPCR) regulate and control the discharge of emissions into the air resources of the State and incorporate the Federal New Source Performance Standards. Louisiana also has adopted the Federal primary and secondary ambient air quality requirements. All facilities are required to obtain a Louisiana Air Emissions Permit, which contains site-specific requirements based on the regulations and the New Source Performance Standards. According to a State official, a facility must be operated in a manner to minimize fugitive dust. If any phosphoric acid, hydrofluoric acid, or alumina facility were to have a potential problem with dust from either a stack or impoundment, the owner or operator would be required to remedy that problem. Options for fugitive dust control are outlined in the regulations and include, among other things, application of chemicals, asphalt, or water.

Mississippi

There are three mineral processing facilities in Mississippi that are under study for this report: two titanium tetrachloride facilities that generate chloride process waste solids, and one phosphoric acid processing facility that generates process wastewater and phosphogypsum. The facilities, their locations, and the waste streams they generate are presented in Exhibit D-2-10.

Exhibit D-2-10
Mineral Processing Facilities Located in Mississippi and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
duPont	Pass Christian	Titanium Tetrachloride	1. Chloride Process Waste Solids
Kerr-McGee	Hamilton	Titanium Tetrachloride	1. Chloride Process Waste Solids
Nu-South Industries	Pascagoula	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum

The Mississippi Hazardous Waste Management Regulations adopt the Federal exemption for wastes from the extraction, beneficiation, and processing of ores and minerals from hazardous waste regulation. Therefore, chloride process waste solids are not regulated as hazardous waste in Mississippi.

The Mississippi Solid Waste Management Regulations contain a provision that exempts solid wastes generated and processed on the generator's property, in a processing facility owned and operated by the generator, from regulation as solid waste [MSWMR Sec. A(2)(f)]. The focus of solid waste regulation implementation has been on municipal solid waste and hazardous waste. There are requirements for solid waste landfills, including liners, ground-water monitoring, and erosion and ponding control. Apart from this focus on municipal solid waste and hazardous waste, the State policy is to allow generators of non-hazardous industrial waste to dispose of the waste on-site without a permit as long as the method of disposal does not create an environmental or public health hazard. The State can and does conduct on-site inspections, and has in some cases required industrial solid waste generators to obtain permits for the disposal of their wastes.

The State does have an approved NPDES program. In addition to NPDES permits for all point source discharges in the State, the State also issues UIC permits, and State permits for discharges to pretreatment works, treatment works where no discharge occurs, and generally where NPDES and UIC permits do not apply. These regulations cover all discharges from industrial facilities, including mineral processing facilities.

The two titanium tetrachloride facilities in Mississippi under study for this report are the duPont facility in Pass Christian, MS and the Kerr-McGee facility in Hamilton, MS. The duPont facility, which uses the chloride-ilmenite process, treats its chloride process waste solids in an on-site surface impoundment and disposes of them in on-site waste pits. It has no solid waste permit for this process or for disposal. It does have a NPDES permit for discharge to surface water from large storage ponds that collect contact cooling water from the production process and surface run-off from all the disposal pits and surface impoundments at the facility. In the past, there had been ground-water monitoring wells on-site, but they are not mandated by the NPDES permit and may not currently be used. The facility is required to monitor the constituent concentrations of its effluent on a regular basis. The Kerr-McGee facility uses the chloride process, and generates process wastewater and chloride process waste solids. The facility has no solid waste permit addressing its co-management of these wastes on-site. Although this facility's NPDES permit closely resembles that of the duPont facility, Kerr-McGee is permitted to discharge its process wastewater while duPont is not. The duPont facility currently injects its process wastewater into the ground via three on-site deep wells.

The phosphoric acid production facility in Mississippi under study for this report is the Nu-South Industries facility in Pascagoula, MS. This facility was recently purchased by Nu-South Industries from Mississippi Chemical Company, which had operated the facility for over 30 years. Since the purchase, the facility has not been in operation and Nu-South has, in fact, filed for bankruptcy. There were no solid waste permits for the facility, but its NPDES permit was transferred to the new ownership. This permit is still in effect, but the only management activities regarding the surface impoundment atop a large phosphogypsum stack which remains at the site are carried on with money provided to the trustee of the facility by Mississippi Chemical Company. According to State officials, inactive or abandoned industrial sites with non-hazardous waste are regulated only in response to demonstrated public health or environmental hazards.

Missouri

Three facilities generate special wastes from mineral processing in Missouri. Each of these facilities generates lead slag. Primary lead slag is the only special waste from the processing of ores and minerals generated in Missouri. Exhibit D-2-11 shows the names and locations of the three lead facilities in Missouri.

Exhibit D-2-11
Mineral Processing Facilities Located in Missouri and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Asarco	Glover	Lead	1. Slag
Doe Run	Herculaneum	Lead	1. Slag
Doe Run	Boss	Lead	1. Slag

Historically, lead slag has not been regulated under either hazardous waste or solid waste rules in Missouri. The Metallic Minerals Waste Management Act passed in 1989, (HB 321), requires generators of lead slag to submit a permit application for management of a number of mining and mineral processing wastes, including lead slag. Permits for existing operations, which were due by February 28, 1990, must include the following: 1) operating information such as maps, proof of ownership, time tables, and location of monitoring wells; 2) a detailed closure plan (and post-closure plan, if applicable), including information on recommended future land uses and plans for revegetation to fit the local environment; 3) an inspection and maintenance plan; and, 4) provisions for financial assurance. Closure plans must be reviewed every five years; plans must include provisions for inspection by State officials. Only active sites are subject to the requirements of the Act; old and abandoned sites are specifically excluded.

Until regulations are developed to implement the Act, owners are not required to meet specific criteria or management requirements beyond the requirement to submit closure plans as described above. The statute contains provisions for enforcement such as injunction and civil penalties. Because the first permitting cycle has not yet been completed, these provisions have not been tested through the failure of a facility to comply with the requirements, or expanded through development of regulations.

In Missouri, owners and operators must obtain a NPDES permit for storm water discharges from slag piles. Therefore, all slag piles should be equipped with run-on/run-off controls. In addition, although lead smelting facilities are required to obtain air quality permits, specific requirements are not included for slag piles. Any dust suppression measures undertaken by facilities are optional.

Montana

Two facilities generate special wastes from mineral processing in Montana. One of these facilities generates lead slag from primary lead production. The other facility generates elemental phosphorus slag. Exhibit D-2-12 shows the names and locations of the two mineral processing facilities in Montana.

Exhibit D-2-12
Mineral Processing Facilities Located in Montana and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Asarco	East Helena	Lead	1. Slag
Stauffer	Silver Bow	Elemental Phosphorus	1. Slag

Two special wastes from the processing of ores and minerals, lead slag and elemental phosphorus slag, are generated by facilities located in Montana. Regulation of lead and elemental phosphorus slag is virtually identical because both wastes are slags and mineral processing waste is not subject to extensive regulation in the State.

Montana has adopted the Federal exclusion from hazardous waste regulation for wastes from the extraction, beneficiation, and processing of ores and minerals.

According to State officials, the Montana solid waste regulations exempt from licensing wastes that are managed on-site. Thus, although lead and elemental phosphorus slags are considered solid waste, as long as slag is managed on-site, a slag pile would not be subject to regulation unless it causes a nuisance or provokes a health hazard. If lead or elemental phosphorus slag were managed off-site, the off-site facility would be subject to solid waste management requirements such as licensing.

Montana does not regulate storm water discharges from slag piles under water quality standards; NPDES permits are not required and slag piles are apparently not required to have run-on/run-off controls. In addition, no surface water or ground-water protection requirements appear to apply to lead slag disposal units.

Although both lead and elemental phosphorus facilities in Montana are required to obtain air quality permits, specific requirements are not included for slag piles. Any dust suppression measures undertaken by facilities related to slag are optional.

New Mexico

There are two mineral processing facilities in New Mexico that are under study for this report. The two facilities are copper processing facilities. Both of the facilities produce furnace slag from copper processing, but neither produce slag tailings or calcium sulfate sludge. The facilities, their locations, and the waste streams they generate are presented in Exhibit D-2-13.

Exhibit D-2-13
Mineral Processing Facilities Located in New Mexico and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Phelps Dodge	Hurley	Copper	1. Slag
Phelps Dodge	Playas	Copper	1. Slag

The New Mexico Hazardous Waste Management Regulations adopt the Federal exemption from hazardous waste regulation for wastes from the extraction, beneficiation, and processing of ores and minerals. Consequently, none of the three special wastes from primary copper processing are regulated as hazardous wastes.

The New Mexico Solid Waste Management Regulations initially defined industrial waste as waste in the nature of residential, commercial or institutional waste generated at an industrial establishment, but not waste resulting from the industrial process. Subsequently, a new set of solid waste regulations was enacted in March 1990. The new regulations specifically exempt wastes from the extraction, beneficiation, and processing of ores and minerals from solid waste regulation.

The New Mexico Environmental Improvement Division is empowered by the New Mexico Water Quality Standards and the New Mexico Water Quality Regulations to establish effluent limitations, to require the highest and best degree of wastewater treatment available to protect the designated uses of State waters, and to enforce both State and EPA discharge permit conditions. The State does not have an approved NPDES program. All persons who may cause or allow effluent or leachate to discharge so that it may move directly or indirectly into the ground water must have a discharge plan approved by the Division. The plans are evaluated on the basis of their adequacy in meeting ground-water quality standards. There are several mining and mineral processing-related exceptions from the universal discharge plan requirement including leachate from the direct natural infiltration of precipitation through disturbed materials (unless the State determines a public health hazard would result) and leachate that is otherwise regulated by the Solid Waste Management Regulations. The State can and does conduct on-site inspections and enforcement actions, including remediation activities. The New Mexico Air Quality Standards and Regulations require all sources of air contaminants to have a permit in order to operate. Although emission limitations for a variety of mineral processing operations are specified, copper processing is not mentioned specifically.

The slag generated at both the Hurley and Playas facilities is not covered under any provision of the State's solid or hazardous waste regulations. Both facilities have discharge plans for protection of the ground water, but the plans do not address slag disposal.

North Carolina

North Carolina has one sodium dichromate facility and one phosphoric acid facility, as shown in Exhibit D-2-14.

In its Hazardous Waste Management Regulations, North Carolina adopts the Federal definition of hazardous waste, and as a result, "solid waste from the extraction, beneficiation and processing of ores and minerals (including coal), including phosphate rock and overburden from the mining of uranium ore" are exempt from regulation as hazardous waste in North Carolina.

Exhibit D-2-14
Mineral Processing Facilities Located in North Carolina and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Occidental Chemical	Castle Hayne	Chromite	1. Roast/Leach Ore
Texasgulf	Aurora	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum

According to State officials, all residuals from facilities with NPDES permits are exempt from the North Carolina Solid Waste Management Act and pursuant regulations.[2] Instead, these wastes are regulated under "non-discharge" permits under the North Carolina Water Pollution Regulations. Under these regulations, a NPDES permit is required to discharge wastes from an outlet, point source, or disposal system into State surface waters. North Carolina has an EPA-approved NPDES program.

North Carolina has issued non-discharge permits to Occidental's chrome facility that require zero discharge from the impoundments used for disposal of the treated residue. In addition, the permit requirements include weekly EP toxicity testing, ground-water monitoring, a compliance boundary where water quality standards must be met, and operation by personnel certified by the State.

For the Texas Gulf facility, much of the disposal activity is addressed under the mining regulations. From 1963 until about two and one half years ago, Texas Gulf placed its phosphogypsum in permanent stacks. According to the State official, they currently stack the phosphogypsum only temporarily. The phosphogypsum is then transported and mixed with clay and sand tailings and put back into mined-out areas. This activity is done under the facility's mining permit. According to the State official, it is Texas Gulf's position that phosphogypsum is not a waste, but rather a by-product. Therefore, the phosphogypsum stacks, both new and old stacks, are not considered waste piles by the Solid Waste Section, and historically, have not been regulated as such. According to the State official, if these stacks fell within the jurisdiction of the solid waste program, the low pH that they exhibit might result in their regulation as hazardous wastes.

According to the State official, North Carolina has adopted Federal effluent limitations guidelines which designate the phosphoric acid process as "closed loop," stipulating that it may not result in any discharge. The Water Quality Section uses best professional technical judgments and best available technology to achieve zero discharge. If zero discharge cannot be achieved, however, the phosphoric acid facilities must abide by State standards for ground water and surface water, as outlined in the North Carolina Water Quality Standards (15 NCAC 2B.02 and .01). These regulations do not allow degradation of the State's waters below water quality levels necessary for existing and future uses.

In all instances, for phosphoric acid facilities, treatment or discharge of wastewater is handled by discharge permits. As noted, North Carolina has an EPA-approved NPDES program. Under the North Carolina Water Pollution Control Regulations, a NPDES permit is required to discharge wastes from an outlet, point source, or disposal system into State surface waters.

The Water Quality Section of the Division of Environmental Management has the primary jurisdiction for the disposal of phosphogypsum and process wastewater from phosphoric acid production and treated roast/leach ore residue from sodium dichromate production. This office has the authority to perform on-site inspections. North Carolina General Statute (143-215.2) addresses and authorizes different types of "special orders," including Consent Orders.

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[2] The North Carolina Solid Waste Management Regulations state that the term solid waste does not include "wastewater discharges and the sludges incidental thereto and generated by the treatment thereof which are point sources subject to permits granted under Section 402 of the Federal Water Pollution Control Act, as amended (P.L. 92-500) and permits granted under G.S. 143-215.1 by the Environmental Management Commission; except that any sludges that meet the criteria for hazardous waste under the Federal Resource Conservation and Recovery Act (P.L. 94-580) as amended, shall also be a solid waste" [NCAC, Title 10, Chapter 10G, Section .0101(36)(iii)].

A State official described a situation at Texas Gulf in which a Consent Order was issued. Depressurizing water for the mine flowed through the stacks. As it passed through one of the ditches around the phosphogypsum, the water became contaminated with fluorides and phosphorus. The Water Quality Section issued a Consent Order. Texas Gulf subsequently "closed the loop" (except for the disposal of cooling water in ponds) to ensure no mingling of waters. Texas Gulf also was required to line all their ditches. As a result of ground-water problems from the ponds and the stacks, another Consent Order was issued. Texas Gulf claims that their ponds are already lined. To address the problem, therefore, they are installing a slurry wall of salted bentonite around these ponds to stop lateral movement to surface water.

A liner or impervious layer is required under all new phosphogypsum stacks in order to reduce migration. At the Texas Gulf facility, according to the State official, no areal expansion of stacks is occurring; instead, the old stacks are typically being drawn down.

Under the North Carolina Air Pollution Control Regulations, the State has adopted the Federal standards for ambient air quality and new source performance standards. According to a State official, the Texas Gulf facility has 21 air permits, none of which specifically mention or address the stacks or ponds. Because the material in gypsum stacks forms a crust, State officials believe that the stacks have not posed a major dust problem, and they have not been actively subject to requirements in the air program. Currently, Occidental's surface impoundment used for disposal of the treated roast/leach residue is not subject to specific requirements in the facility's air permit.

In the future, however, the State official mentioned a recently promulgated air regulation that may affect the phosphogypsum stacks and ponds and chrome waste impoundments. When Texas Gulf or Occidental modifies its facility and applies for a new permit, the stacks or impoundments may become subject to more stringent air regulation under the Control of Toxic Air Pollutants (15A NCAC 2D Section .1100) and the permitting requirements for toxic air pollutants (15 NCAC 2H Section .0610). This regulation addresses certain air toxics, including radionuclides and fluorides, which can be released as air contaminants from phosphogypsum stacks and ponds.

North Dakota

As seen in Exhibit D-2-15, the Dakota Gasification facility in Beulah, North Dakota is the only facility in the State under study for this report.

Exhibit D-2-15
Mineral Processing Facilities Located in North Dakota and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Dakota Gas	Beulah	Coal Gasification	1. Process Wastewater 2. Gasifier Ash

Under the North Dakota Hazardous Waste Management Act, "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore" is exempt from regulation as hazardous waste. North Dakota has an EPA-approved RCRA Subtitle C program.

The North Dakota Solid Waste Management Regulations delineate standards for several disposal operations, including sanitary landfills, incinerators, special use disposal (i.e., construction and demolition wastes and incineration residue), and other methods of disposal. The North Dakota State Department of Health and Consolidated Laboratories, in its comment on the September 25, 1989 proposed mineral processing rule (54 FR 39298), stated that wastes from the Dakota Gasification facility are regulated as "special wastes" (i.e., special use) under the State's Solid Waste Management and Land Protection Act and the Solid Waste Management Regulations.[3] According to a State official, the Department is given broad authority under the Act to implement the pursuant rules, so long as its actions are within the intent of the Act.

Under authority of the Special Use Disposal Standards (33-20-05-02), the Department of Health determines the appropriate requirements for each site and outlines them in a permit. Permits are required in order to construct (33-20-06-08) and operate (33-20-07-01) a solid waste disposal facility. The State official described three permitted disposal facilities, two landfills for gasifier ash, one of which is closed, and one for construction debris. The ash landfills are required to have liners. The ash landfill currently in use has a synthetically lined run-off system and a tiled drain system on the up-gradient side, outside of the pit.

One ash landfill has been closed, and the "permit is under post-closure." According to a State official, at the time of closure the permit is amended and post-closure requirements are attached. Closure requirements include eight feet of cover, where the lower three feet are of compacted clay. Post-closure requirements include general maintenance and ground-water monitoring.

The facility's four ponds do not have permits, although proposed rules (see below) would require them. At the time of the plant's construction, it was unclear whether the process waters would exhibit hazardous characteristics, and subsequently which regulations would apply. The State official noted that a conservative approach was taken and liners and other engineered controls were used.

The Department of Health has right-of-entry authority to conduct on-site inspections, issue administrative orders (e.g., the Director may issue a Directive in emergency situations), enter into consent agreements, and take civil or criminal action.

North Dakota is currently in the process of amending its solid waste regulations. The proposed changes include specific requirements for surface impoundments, including permitting requirements, and express post-closure care activities for all disposal facilities. Neither the current rules nor the amendments have express financial responsibility requirements.

The North Dakota Water Pollution Control Act establishes the requirements for treatment of industrial wastes. The North Dakota Water Quality Standards require that no untreated industrial wastes which contain substances harmful to the public or which would degrade water quality can be discharged into the State's waters. The North Dakota Pollution Discharge Elimination System Regulations establish procedures for application, issuance, denial, modification, and revocation of permits for discharging pollutants into the waters of the State. North Dakota participates in the National Pollutant Discharge Elimination System (NPDES). NPDES permit holders are required to comply with Federal effluent limitations and other applicable requirements of the Water Pollution Control Act.

The North Dakota Air Pollution Control Rules (NDAPCR) establish air quality standards and emission requirements necessary to maintain air quality. NDAPCR outlines ambient air standards similar to Federal standards, except for the sulfur oxides standard, which is more stringent. The rules include provisions for restriction of particulate matter from industrial processes. Permits are required in order to construct and operate air contaminant sources. According to State officials, the air permit for the Dakota Gas facility does not directly address the waste management units.

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[3] North Dakota State Department of Health and Consolidated Laboratories, MW2P-00002, Public Docket MW2P-FFFFF, U.S. EPA.

Ohio

Eight facilities generate special wastes from mineral processing in Ohio. Seven of these facilities are fully integrated ferrous facilities generating iron and basic oxygen steel slag and air pollution control dust and sludge (Wheeling-Pittsburgh, Steubenville did not generate steel wastes in 1988). The other facility generates titanium tetrachloride process waste solids. Exhibit D-2-16 shows the names and locations of the mineral processing facilities in Ohio.

Exhibit D-2-16
Mineral Processing Facilities Located in Ohio and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Armco	Middletown	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furance APC Dust/Sludge
LTV Steel	E. Cleveland	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furance APC Dust/Sludge
LTV Steel	W. Cleveland	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furance APC Dust/Sludge
US Steel	Lorain	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furance APC Dust/Sludge
Warren Steel	Warren	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furance APC Dust/Sludge
Wheeling-Pittsburgh Steel	Steubenville	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge Steubenville did not generate steel wastes in 1988
Wheeling-Pittsburgh Steel	Mingo Junction	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furance APC Dust/Sludge
SCM	Ashtabula	Titanium	1. Titanium Tetrachloride Process Waste Solids

Seven facilities in Ohio generate ferrous wastes; one facility generates titanium tetrachloride process waste solids.

Ohio adopts the special exemption for wastes from the extraction, beneficiation, and processing of ores and minerals. Therefore, neither the special ferrous wastes nor chloride process waste solids from the production of titanium tetrachloride are regulated as hazardous wastes in Ohio.

According to the Ohio Solid Waste Disposal Regulations, slag is not a solid waste, and therefore slag from iron and steel production is not regulated as a waste under Ohio waste management rules. The re-use of slag, however, may be subject to specific statements or requirements.

Despite Ohio's adoption of the special waste exclusion, State officials indicated that iron and steel APC dust or sludge as well as titanium chloride process waste solids could be regulated as a hazardous or solid waste, depending on the results of EP toxicity tests. Assuming that in most instances hazardous waste regulation is avoided through the special exemption, ferrous APC dust and sludge and titanium chloride process waste solids would be regulated as solid waste. State officials explained that they use a strict interpretation of solid waste, and that all wastes that are not hazardous or are not specifically excluded by the solid waste regulations, such as slag, are regulated as solid waste. Thus, ferrous APC dust and sludge and titanium tetrachloride process waste solids are regulated as solid, non-hazardous wastes according to State officials.

Generators of solid waste are authorized to dispose of their waste in one of three ways: incineration, landfill disposal, or composting. If wastes are incinerated on-site, then the facility does not need a permit. Water pollution control regulations apply to some aspects of the land application of sludges. Ohio has no specific storage requirements for non-putrescible wastes; thus, the storage time for these wastes is open-ended, according to State officials.

If APC dust and sludge or titanium tetrachloride waste solids were regulated as solid waste in accordance with the interpretations of the State officials contacted, generators could only dispose of waste at landfills meeting the revised requirements for solid waste management that became effective on March 1, 1990. All such wastes must meet the "paint filter test" to determine that there are no free liquids in the waste. Furthermore, wastes must not display a characteristic of hazardous waste. The Ohio EPA has authorization to inspect any licensed solid waste disposal facility. Inspections are carried out in cooperation with approved local health departments. State officials noted that approved local health departments inspect industrial as well as sanitary landfills. Violations of any aspect of the solid waste regulations are considered felonies and are punishable by financial penalties of up to $25,000 and a three year jail term per day per violation.

As of March 1, 1990 all licensed facilities must have met a variety of requirements, including ground-water monitoring, placement of a final cap at closure, financial assurance, and a closure and thirty year post-closure period (some exceptions were provided for financial assurance mechanisms). A call-in schedule has been established for facilities to obtain new permits. Within two to three years all facilities will have reported to the Ohio EPA for a revised permit.

Any site that has been in operation and closed over the last twenty years and is within 305 meters (1,000 feet) of an occupied structure, must establish an explosive gas monitoring plan and network. The new requirements include provisions for leachate collection systems and sedimentation basins for ground water; any discharge into waters of the State must be made in accordance with a NPDES permit.

Increasingly, according to State officials, landfills are subject to fugitive dust controls and require permits. Typically, however, no air monitoring is required. Air and water controls are not required for slag piles unless they are established through general provisions in the appropriate permits on a case-by-case basis. State officials noted that they have broad site-specific authority to establish controls as needed.

Any restrictions on the use of wastes, such as slag, are usually established by the water program through a monitoring plan which provides for an approved mechanism for waste management on most sites.

Officials in Ohio were able to provide a significant amount of information regarding the regulation of waste at specific ferrous facilities as well as at SCM.

The following describes the permits that Ohio State officials report ferrous metals production facilities have, and the disposal methods that the facilities reported for blast furnace APC dust and/or sludge in the National Survey of Mineral Processors:

Armco:
- Has its own permitted solid waste disposal facility on-site.
- Reports that it disposes on-site.

LTV:
- One or both of the LTV facilities brings its wastes to an independent landfill, according to State officials.
- Reports that it disposes on-site.

US Steel:
- Has no licensed landfill, according to State officials.
- Reports stockpiling waste in a waste pile.

Warren:
- Has no licensed landfill, according to State officials.
- Reports stockpiling some waste in a waste pile and returning some or all to the blast furnace.

W-P Steel:
- (Mingo Junction and Steubenville) have no licensed landfills, according to State officials.
- (Mingo Junction) reports sending waste off-site for disposal. (Steubenville did not report its management of blast furnace APC dust and sludge.)

Because these facilities do not have permits for on-site landfills, under the solid waste regulations they may: 1) transport waste to a permitted landfill off-site; 2) incinerate waste; or 3) compost waste. It is extremely unlikely that ferrous metal APC dust and sludge is incinerated or composted. Thus, according to State officials' interpretation of the solid waste regulations, ferrous metals facilities should be disposing of APC dust and sludge off-site. According to the responses summarized above, however, one facility disposes waste off-site, and one facility disposes waste on-site in a permitted landfill. It is possible that a certain percentage of APC sludge is sent to wastewater treatment works (e.g., a regulated lagoon that would meet requirements established for wastewater treatment and water quality).

Ohio State officials report that the SCM facility is required to have an Ohio EPA solid waste permit for landfilling their solid waste, and an annual operating license. The SCM waste is considered a solid waste. SCM has applied for a license for a new solid waste management facility.

SCM did not have a solid waste management license in 1989. If the facility had a landfill or other solid waste management operation in 1989, it was closed, according to State officials in Ohio. Regulated alternatives for disposal of chloride solids include disposing solids in a closed-out lagoon that would be regulated by the Division of Water Pollution Control, or in a hazardous waste management unit regulated by Ohio's RCRA unit. SCM reported in its response to the National Survey of Mineral Processors that all titanium chloride process waste solids were recycled and none were disposed. This may have alleviated the need to dispose of the waste solids in the absence of a licensed waste management facility.

As outlined above, Ohio does not have specific storage requirements that would apply to ferrous APC dust and sludge or titanium process chloride waste solids. Thus, either of these wastes may escape regulation if stored for extended periods of time. For instance, as described above, a number of ferrous facilities may stockpile APC dust and sludge in waste piles indefinitely.

Pennsylvania

Seven facilities generate special wastes from mineral processing in Pennsylvania. Six of these facilities are fully integrated ferrous facilities generating iron and basic oxygen steel slag and air pollution control dust and sludge. One facility (US Steel, Fairless Hills) generates steel open hearth furnace slag and dust as well.

The last facility generates zinc slag from primary zinc production. Exhibit D-2-17 shows the names and locations of the mineral processing facilities in Pennsylvania.

The similar nature of zinc slag and ferrous wastes, as well as their joint classification in Pennsylvania as residuals waste, results in virtually identical regulation of the ferrous and zinc mineral processing wastes.

Exhibit D-2-17
Mineral Processing Facilities Located in Pennsylvania and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Allegheny Ludlum	Brackenridge	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge
Bethlehem Steel	Bethlehem	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge
Sharon Steel	Farrel	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge
Shenango	Pittsburgh	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge
US Steel	Fairless Hills	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge 5. Open Hearth Furnace Slag 6. Open Hearth Furnace APC Dust/Sludge
US Steel	Braddock	Ferrous	1. Blast Furnace Slag 2. Blast Furnace APC Dust/Sludge 3. Basic Oxygen Furnace Slag 4. Basic Oxygen Furnace APC Dust/Sludge
Zinc Corporation of America	Monaca	Zinc	1. Slag

At this time, ferrous metal production wastes and zinc slag are not regulated as either hazardous or solid waste in the State of Pennsylvania, although these wastes are subject to regulation as residual waste. Pennsylvania has exempted waste from the extraction, beneficiation, and processing of ores and minerals from hazardous waste regulation. The solid waste regulations establish requirements for municipal waste which generally consists of waste from municipal, residential, commercial and institutional establishments and community activities. A proposed rule published February 24, 1990 defines residual waste as:

> Garbage, refuse, other discarded material or other waste, including solid, liquid, semisolid or contained gaseous materials resulting from industrial, mining, and agricultural operations and sludge from an industrial, mining or agricultural water supply treatment facility, waste water treatment facility or air pollution control facility, if it is not hazardous (Pennsylvania Bulletin, Vol. 20, No. 8, 2/24/90).

State officials noted, as an indication that ferrous and zinc slag (and presumably ferrous APC dust and sludge) would be regulated as residual waste under the proposed rule, that the proposed rule specifically refers to a zinc slag pile ("mountain") as an example of residual waste (Pennsylvania Bulletin Vol. 20, No. 8, 2/24/90).

Presently, residual wastes are subject to regulation only at the point of disposal. A slag pile used as a disposal site must have a permit. For the most part, however, wastes that are stored (for less than one year) for later use or re-processing do not require a permit. The issue of storage leads to a conflict between industry and State officials over how long storage (particularly of iron and steel slag) should be allowed without a permit. Under the current regulations, storage in excess of one year constitutes illegal disposal. State officials and industry still disagree on the implementation of this requirement. For instance, Bethlehem Steel in Bethlehem, PA has at least one permit for disposal of residuals resulting from the production of iron and steel. The State and Bethlehem disagree, however, on exactly how the permit should be interpreted, and thus iron and steel slag is managed (or stored long term) without a permit. PADER has not required permits for the zinc slag piles at the Monaca facility.

Under the current residuals regulations (Industrial and Hazardous Waste Disposal Sites, §75.38), a permit is not required for transportation of solid waste off-site. Landfills that are permitted to receive residual waste usually must have a permit for municipal waste with an amendment to receive residuals. These landfills must use a system of double liners. Facilities must submit a permit application with a map; a leach test of the waste; and a ground-water study, including the test results of three borings (at least one up- and one down-gradient of the landfill). Phase II of the present residual rule requires landfills without liners to be above the high-water table, and to have "renovating" soil underneath. After closure the site must be re-vegetated with at least two feet of soil.

The Proposed Residual Waste Regulations, which may be finalized before the end of 1990, will establish requirements for management of residual waste, including zinc slag and ferrous wastes, similar to the Pennsylvania requirements for municipal solid waste management. State officials suggested that some industries may be granted exemptions from the rule. In particular, exemptions could be granted for materials that are re-used or re-processed. This could mean that iron and steel slag that is sold for processing, and perhaps APC dust/sludge that is re-processed, could be exempted from regulation under the final residuals rule.

The structure of the proposed regulations closely follow the Pennsylvania Solid Waste Regulations. Depending on the results of leach tests, ferrous wastes as well as zinc slag may be placed in three different types of landfills with various liner and other requirements. Generators will be required to file a form stating that they have attempted to reuse and/or recycle the waste before disposal. As with the solid waste regulations, permits will be required that include provisions for liners, leachate collection systems, monitoring wells, and disposal of leachate. The proposed rule is also similar to the municipal waste regulations with regard to prohibitions on where facilities may be located (e.g., within the 100 year floodplain, over areas of limestone). It is unclear at this time how the final regulation will address inactive or abandoned sites, although the proposed rule indicates that facilities without permits must document closure procedures within a certain time frame.

Water regulation of ferrous metal production wastes and zinc slag in Pennsylvania is primarily determined on a case-by-case basis. Although the State has authority to regulate discharge from slag waste piles, State personnel indicated that discharge limits would most likely be established only if there was evidence of contamination. If facilities channel run-off to lagoons or storm water discharge basins, the effluent would be sampled and the facility would be required to meet certain contaminant limits. State drinking water standards could also be invoked. Legally, facilities are not required to report on the storage of waste. Thus, particularly in the case of iron and steel slag that is stored speculatively, the State might not have the authority to require controls for a slag pile that is considered a storage pile for an indefinite period. Run-off from unlined zinc or ferrous slag piles or ferrous APC dust and sludge piles could be very difficult to collect. Thus, contaminated run-off may not be subject to any State controls.

Air regulations in Pennsylvania apparently apply mainly to processes that generate air emissions. The department does not regulate air emissions from waste disposal and management activities. According to one State official, if a complaint was received regarding fugitive dust emissions from a mineral processing type facility, the inquiry would be referred to the waste management division.

Tennessee

There are three mineral processing facilities in Tennessee that are under study for this report: two elemental phosphorus processing facilities that generate slag and one titanium tetrachloride facility that generates chloride process waste solids. The facilities, their locations, and the waste streams they generate are presented in Exhibit D-2-18.

Exhibit D-2-18
Mineral Processing Facilities Located in Tennessee and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
duPont	New Johnsonville	Titanium Tetrachloride	1. Chloride Process Waste Solids
Rhone-Pulenc	Mt. Pleasant	Elemental Phosphorus	1. Furnace Slag
Occidental	Columbia	Elemental Phosphorus	1. Furnace Slag

The Tennessee Hazardous Waste Management Regulations exempt wastes from the extraction, beneficiation, and processing of ores and minerals from regulation as hazardous waste. Therefore, neither chloride process waste solids nor elemental phosphorus slag are regulated as hazardous waste in Tennessee.

The Tennessee Solid Waste Regulations include industrial waste in its definition of solid waste; however, prior to 1981, if the industrial waste was disposed on-site, then it was not regulated at all under the solid waste regulations provisions. In 1981 new regulations were enacted that developed classes and design and operating standards for on-site and off-site solid waste landfills. These regulations focused almost exclusively on municipal solid waste (Class I landfills) and, although industrial waste landfills were designated and regulated as Class II landfills, enforcement of the standards was not vigorous. Another new set of regulations, however, came into effect in March 1990. These regulations require various management practices for both Class I and Class II landfills, including approval of design drawings, contouring plans, liners, leachate collection systems or other vertical buffers, and conditional ground-water monitoring. Any new solid waste disposal facility must meet these requirements, while existing facilities are granted a four year grace period to comply. The regulations also include requirements for financial assurance for closure and 30 years of post-closure care. The State can and does conduct on-site inspections and enforcement actions. Most of the resources are still focused on municipal solid waste, and it will take time to bring all the old landfills into compliance with the new regulations.

The Tennessee Water Quality Control Act requires a permit for various activities, including the development of any natural resource. The State has an approved NPDES program, and both the Occidental Chemical facility in Columbia and the Rhone-Pulenc facility in Mt. Pleasant have obtained an NPDES permit for discharges from their elemental phosphorus processing activities. The effluent restrictions are based on the Federal effluent guidelines and on the level of treatment necessary to protect the receiving waters. The permits include requirements for bio-monitoring and allude to the necessity of compliance with solid waste management requirements in the Tennessee Solid Waste Disposal Act and the Tennessee Hazardous Waste Management Act. The Occidental facility has a permit for an onsite industrial landfill which receives any non-hazardous process wastes. The Rhone-Pulenc facility had an on-site permit, reached a point where they reprocessed some of the material in the waste pile, and then finally removed all waste from the site. It is the current practice of both facilities to attempt to sell all the furnace slag that is generated to a reuser. The quantity that is not sold is stockpiled on-site or landfilled at a permitted municipal landfill.

The titanium tetrachloride facility in Tennessee that is under study for this report is the duPont facility in New Johnsonville, TN. It currently produces chloride process waste solids which are treated and landfilled. The duPont facility has received solid waste landfill permits in 1977, 1978, 1981, 1986, and 1987 for a number of landfills which the facility utilizes to dispose of different types of waste generated on-site. The facility also has a NPDES permit to discharge from the on-site surface impoundment used to treat process wastes. This permit includes requirements for effluent monitoring, bio-monitoring, and for compliance with State solid and hazardous waste management regulations in the management of any sludge or solid material generated in the wastewater treatment process.

Texas

Texas has one phosphoric acid facility, two hydrofluoric acid facilities, one chrome facility, one alumina facility, and three copper facilities, as outlined in Exhibit D-2-19.

Exhibit D-2-19
Mineral Processing Facilities Located in Texas and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Alcoa	Point Comfort	Bauxite	1. Red and Brown Muds
Reynolds	Gregory	Bauxite	1. Red and Brown Muds
American Chrome	Corpus Christi	Chromite	1. Roast/Leach Ore
ASARCO	Amarillo	Copper	1. Slag
ASARCO	El Paso	Copper	1. Slag
Phelps Dodge	El Paso	Copper	1. Slag
duPont	LaPorte	Hydrofluoric Acid	1. Process Wastewater 2. Fluorogypsum
Mobil Mining	Pasadena	Phosphoric Acid	1. Process Wastewater 2. Phosphogypsum

Texas administers an authorized Subtitle C program. According to State officials, the Texas Hazardous wastes program closely models RCRA, incorporating the Federal exclusion for mineral processing wastes.

The Texas Industrial Waste Management Regulations establish standards for all aspects of the management and control of municipal hazardous waste and industrial solid waste. According to State officials, the mineral processing facilities in this State discussed in this report are subject to only one express requirement, the notification stipulation (TAC, Title 31, §335(a),(f),(g)) of the regulations, in order to dispose of their respective special wastes. Owners or operators were and are required to notify the Texas Water Commission 90 days prior to the onset of disposal activities and may be required to submit any of the following information: waste composition, waste management methods, facility engineering plans, and the geology where the facility is located. Ninety-day advance notice for expansion or closure is also required. The owner or operator is required to submit details of closure activities if requested by the Texas Water Commission. The TWC can initiate enforcement activity against a firm if the closure activities are deemed inadequate. Under the General Prohibitions (§335.4), owners and operators are not allowed to discharge industrial solid waste into the waters of the State without specific authorization from the TWC.

According to State officials, of the three Texas copper facilties, only Asarco's El Paso facility is subject to the requirements of these regulations. The Asarco facility in Amarillo and Phelps Dodge's facility in El Paso reuse their copper slag and are not subject to these regulations.

No solid waste disposal permit is required at the facilities for disposing phosphogypsum and process wastewater from phosphoric acid production; fluorogypsum and process wastewater from hydrofluoric acid production; red muds from alumina production; treated roast/leach ore residue from sodium dichromite production; and slag, calcium sulfate sludge, and slag tailings from primary copper processing because these wastes are disposed on properties that are: (1) located within 50 miles of the facilities where they are generated; and (2) owned or controlled by the owner/operator of the facilities. These facilities do have "registrations", which are essentially inventories of the wastes generated and the manner in which they are managed.

According to a State official, the regulations do not outline specific requirements for waste piles or surface impoundments that manage industrial solid waste. Owners or operators are not expressly required to place liners under the impoundments or to monitor ground-water. No closure and post-closure care requirements exist for industrial solid waste piles or impoundments. These facilities are not required to maintain a surety bond for financial assurance. The Texas Water Commission does provide ten Technical Guidelines to advise owners/operators on appropriate liner materials and thickness, closure and post-closure care activities, and site selection criteria, among other things. According to a State official, these Guidelines merely advise and recommend; they do not outline requirements.

Texas does not have an EPA-approved NPDES program. The Texas Water Quality Acts state that no person may discharge "industrial waste into or adjacent to any water of the State" without a permit. As a result, Texas has a "dual permitting system" in which both a Federal NPDES and a State Wastewater Discharge Permit are required for wastewater discharges to surface waters. The Mobil phosphoric acid facility and the duPont hyrdrofluoric acid facility have both. According to a State official, Reynolds does not have a NPDES permit and does not discharge to surface water. State permit requirements are outlined in the Texas Wastewater Treatment Regulations. The regulations set specific discharge limits and stipulate that process water must be retained in a surface impoundment capable of retaining maximum process flow without allowing any discharge of pollutants. If discharge of these waters can be prevented by retention, a permit is not required. According to a State official, a State discharge permit may address discharge of process wastewater and discharge of contaminated or non-contaminated storm water ponds.

According to a State official, of the three copper facilities in this State addressed by this report, the Asarco facility in El Paso is the only one that is subject to the Texas Water Quality Acts (Title 2, Chapter 26 of the Texas Administrative Code) and the Water Quality Standards for its slag disposal activities. The facility must ensure there will be no contamination of ground water or surface water from slag disposal activities. Run-off controls may be required in order to ensure compliance with this requirement. The water quality standards set site-specific limits to ensure no degradation of water bodies. According to a State official, the Asarco plant is under an enforcement order as a result of run-off from slag piles into the Rio Grande River. High levels of arsenic were found. Asarco has since built an impoundment to collect storm water run-off.

The Texas Clean Air Act generally prohibits any emission without a permit, which is issued by the Texas Air Control Board. In general, these permits for these facilities mainly address emissions from the respective production processes, and waste disposal units are subject only to general requirements within the permit. According to State officials, no requirements of the Act apply to the copper slag generated at Amarillo or the Phelps-Dodge/El Paso facilities because any slag produced is reused and not disposed. According to a State official, copper slag produced and disposed at the Asarco facility in El Paso also is not subject to air requirements, such as water spraying and chemical sealing for control of fugitive dust from slag piles, because the material hardens as it cools. Historically, fugitive dust has not posed a problem.

The Alcoa and Reynolds facilities have permits from the Texas Air Control Board. According to a State official, the permit mainly addresses emissions from the production process and, therefore, the surface impoundments at these facilities are subject only to general requirements within the permit. The State official mentioned that at both facilities, the surface impoundments used for the disposal of the muds have needed modifications. In both instances, the impoundments were drying up, causing fugitive dust emissions problems. At Reynolds, there was an enforcement action for violation of a permit requirement, and the Air Pollution Board has had complaints about the Alcoa/Point Comfort plant. Reynolds now uses a flooding process to keep the muds completely under water, employing water from the nearby (saltwater) bay. Alcoa puts a coarse river sand over areas that become dry in order to control emissions.

According to the State official, the Texas Clean Air Act is the main piece of legislative authority for the Texas Air Pollution Board. Air Regulation No. 6 requires that a permit be obtained for construction or modification of a facility that would emit air contaminants. According to the State official, by requiring a permit to modify a facility, this regulation picks up the "grandfathered" facilities that were constructed prior to the cutoff date for "new" facilities. The permit system requires the use of Best Available Control Technology.

Utah

There are three mineral processing facilities in Utah that are under study for this report: a magnesium facility that generates process waste water, a copper processing facility that generates slag, slag tailings and calcium sulfate sludge, and a ferrous metals facility that generates iron blast furnace and steel open-hearth furnace slag and APC dust and sludge. The facilities, their locations, and the waste streams they generate are presented in Exhibit D-2-20.

Exhibit D-2-20
Mineral Processing Facilities Located in Utah and the Waste Streams They Generate

Facility	Location	Sector	Waste Streams
Nagcorp	Rowley	Magnesium	1. Process Wastewater
Kennecott	Garfield	Copper	1. Slag 2. Slag Tailings 3. Calcium Sulfate Sludge
Geneva	Orem	Ferrous	1. Open-hearth Slag 2. Oepn-hearth APC Dust/Sludge 3. Iron Blast Furnace Slag 4. Iron Blast Furnace APC Dust/Sludge

According to State officials, the language of the Utah Solid and Hazardous Waste Act was developed in an attempt to provide a flexible scope with respect to both solid and hazardous waste regulation. The Utah Hazardous Waste Regulations exempt wastes from the extraction, beneficiation and processing of ores and minerals from regulation as hazardous waste and Section 26-14-6 of the Solid and Hazardous Waste Act exempts those wastes from the scope of rulemaking as solid wastes. As a result, none of the special wastes from primary copper processing, magnesium processing or ferrous mineral processing are specifically addressed by the State solid or hazardous waste regulations.

Section 26-14-6, however, also provides for the regulation of extraction, beneficiation, and processing wastes as hazardous wastes under certain conditions. More specifically, if a waste is either listed by EPA as hazardous waste or is determined to be hazardous through the evaluation of the waste against hazardous waste criteria, it will fall under the State's hazardous waste regulatory program. Once EPA makes a determination on the status of the currently exempt special mineral processing wastes, those wastes will be addressed by the State's regulatory program in accordance with that decision, i.e., Utah's position with respect to the 20 special mineral processing wastes will parallel that of EPA.

The State has an approved NPDES program and the State Water Pollution Control Committee is empowered by the Utah Water Pollution Control Act to promulgate water quality standards, classify State waters, promulgate and enforce effluent limitations, and issue discharge permits. The State can and does conduct on-site inspections, as well as enforcement actions if the facility is found to be in violation of a permit. As of January 1990, new ground-water protection legislation was enacted and the new ground-water office is in the process of designing ground-water discharge permits. No such permits have been issued as yet.

The tailings impoundment that is used for disposal of slag tailings at the one primary copper processing facility in Utah also receives tailings from ore beneficiation, run-off, and discharges from all of the facility's various operations. Discharge from the impoundment to a Class VI surface water is controlled under the conditions of a NPDES permit. The designated use for a Class VI water in Utah is defined as "special," and waters with this classification are generally not suitable for any of the other beneficial uses designated by the State. Discharge standards for Class VI receiving waters are determined on a case-by-case basis. The State is in the process of negotiating a new NPDES permit that will include bio-monitoring provisions in addition to existing BMP requirements. EPA Region VIII is taking a special interest in the terms of this permit because of the designation of the receiving waters, under the Clean Water Act, as a special impaired area.

The Utah Air Conservation Regulations specifically regulate sulfur dioxide air emissions and visible compounds from the primary copper processing operations at the Kennecott facility. Fugitive dust emissions from tailings piles and ponds at the facility are not specifically regulated but are covered by the general fugitive dust control requirements for tailings ponds and piles in Utah. Management practices that may be required for dust control include watering and/or chemical stabilization, synthetic or vegetative covers, wind breaks, and restrictions on the speed of vehicles in and around tailings operations.

Under the provisions of Title 26, Chapter 11 of the Act, a Utah Pollutant Discharge Elimination System Permit has been issued to the Magcorp magnesium facility that requires the facility to have no discharge to surface waters. The permit also requires the facility to monitor pH on a quarterly basis in a test well adjacent to the impoundment and in standing water between the impoundment dikes and the Great Salt Lake. Monitoring results that indicate pH values outside of the range of 6.5 to 9.0 must be reported to the State and EPA within seven days. Based on review of the monitoring data, Magcorp may be required to develop and implement a plan to eliminate seepage from the impoundment. Any plans developed require approval prior to implementation.

The ferrous metal facility in Utah under study for this report is the Geneva facility in Orem, Utah. It generates iron blast furnace slag and APC dust and sludge and steel open-hearth furnace slag and APC dust and sludge. The facility recycles its slag by selling it to a recycler that is located on or near the Geneva facility itself. According to State officials, none of these wastes are regulated under the State's solid waste authority, and the only permits that exist for the facility are air and water quality permits. The facility is currently involved in negotiating a new NPDES permit with EPA and has just reached a tentative settlement agreement with EPA in response to a permit violation. According to the State official, the new permit will include new bio-monitoring requirements and more stringent ammonia effluent limitations. The permitted discharge is from a retention basin that collects all run-off from the site. Although State air quality regulations require general fugitive dust control measures, there was no confirmation by State officials that those measures were in place at the Geneva facility.

Appendix E

Cost and Economic Impact Assessment Methodology, Assumptions, and Results

Appendix E-1

RCRA Subtitle C Statutory and Regulatory Provisions

Appendix E-1

RCRA Subtitle C Statutory and Regulatory Provisions

1. Definition of a RCRA Hazardous Waste CFR § 261.3:

1) The waste is or contains a hazardous waste listed in Subpart D of Part 261; or

2) The waste exhibits any of the characteristics in Subpart C of Part 261: ignitability, corrosivity, reactivity, or EP toxicity.

   a) May be **exempted under 261.4(b)** - solid wastes that are not hazardous wastes include:

      - mining overburden returned to mine site;
      - fly ash waste, bottom ash waste, and flue gas emission control waste generated primarily from the combustion of coal or other fossil fuels;
      - solid wastes from the extraction, benefication and processing of ores and minerals (including coal), including phosphate rock and overburden from the mining of uranium ore; and
      - wastes that fail the test for the characteristic of EP toxicity because chromium is present or are listed in Subpart D because chromium is present, wastes that do not fail the test for the characteristic of EP toxicity for any other constituent or are not listed due to the presence of any other constituent, and wastes that do not fail the test for any other characteristic if shown by a generator that:
      - the chromium in the waste is exclusively or nearly exclusively trivalent chromium;
      - the waste is generated from an industrial process that uses trivalent chromium exclusively or nearly exclusively and the process does not generate hexavalent chromium; and
      - the waste is typically and frequently managed in non-oxidizing environments.

   b) May be **exempted under § 260.22** - Petition to amend Part 261 to exclude a waste from a particular facility. A person seeking to exclude a particular waste from the list of wastes in Subpart D must show that the waste does not exhibit any of the criteria under which the waste was listed as hazardous. The Administrator can look at constituents in the waste other than those that the waste was listed for. Even though the waste may be de-listed, it may still exhibit hazardous characteristics and, thus, be regulated under Subpart C.

2. Hazardous Waste Regulations Generally

- If generated by a conditionally exempt small quantity generator (SQG), waste is subject to provisions under § 261.5. A conditionally exempt SQG is a generator that generates 100 kilograms or less of hazardous waste a month.
- If intended to be legitimately and beneficially used, re-used, recycled, or reclaimed and is a sludge or is a listed hazardous waste (Part 261, Subpart D) or is a mixture containing a listed waste, it is subject to the following regulations with respect to transportation and storage:
  - Notification under RCRA § 3010. All persons generating, transporting, treating, storing, or disposing hazardous waste must notify EPA.

    - Parts 262 and 263. Part 262 concerns requirements for generators of hazardous waste. Part 263 concerns standards applicable to transporters of hazardous waste.
    - Part 264, Subparts A through E. Part 264 sets forth standards that apply to owners and operators of treatment, storage, and disposal facilities.
    - Part 265, Subparts A through E, G through J, and L. Sets forth requirements that apply to facilities that have not received a permit.
    - Parts 270 and 124. Parts 270 and 124 set forth permit requirements.
- If not intended to be legitimately and beneficially used, re-used, recycled, or reclaimed then is intended to be discarded and subject to subtitle C regulations:
    - Part 262 - Generators
    - Part 263 - Transporters
    - Parts 264 and 262.34 - Owners/operators of TSD facilities - on-site generators storing waste less than 90 days for subsequent shipment off-site.
    - Part 265 - Owners/operators of TSD facilities who qualify for interim status must apply for a permit.
    - Part 270 - Owners/operators of TSD facilities who do not qualify for interim status must apply for a permit.

3. Permit Requirements

- A RCRA permit must be obtained by persons who treat, store, or dispose of wastes that:
    1) have been removed from the Mining Waste Exclusion, and
    2) are characteristically hazardous or are listed hazardous wastes.

Notification

Persons who treat, store, or dispose of hazardous waste must file a notification with the Administrator within 90 days of the final rule that removed the wastes from the Bevill exemption (by April 23, 1990). The notification must state the location and description of the facility and the identified hazardous wastes handled.

- If the person is in a State that has an authorized hazardous waste permitting program, notification will be required after the State receives authorization or amends its program to regulate these wastes.

Permit Application Made in Two Parts

a) Part A Permit Application

- Timely submission of notification and a Part A application qualifies an existing facility for interim status. The requirements for interim status facilities are described in section 4 below.

b) Part B Permit Application

- The Regional Administrator or the State Director will request a Part B application; facilities will be notified 6 months before the Part B application is due. Owners and operators of land disposal facilities must submit Part B applications within 12 months of the effective date of the regulations. The requirements for fully permitted facilities are set out in sections 5 through 15 below.

4. Interim Status

Applicability

- The Federal standards for interim status facilities apply to owners and operators (O/Os) of existing treatment, storage, and disposal facilities:
  - who have fully complied with the notification requirements and the Part A permit application requirements until either a permit is issued or until closure and post-closure responsibilities have been met; or
  - who have failed to obtain interim status.
- The standards do not apply to:
  - persons disposing of hazardous waste by means of ocean disposal under a permit issued under the Marine Protection, Research, and Sanctuaries Act;
  - O/Os of a POTW that treats, stores, and disposes of hazardous waste;
  - persons who treat, store, and dispose of waste regulated by a RCRA authorized State;
  - O/Os of a facility managing recyclable materials **(261.6 (a)(2) and (3))** (see list in Part 264 standards, section 5 below);
  - a generator accumulating hazardous waste on-site for less than 90 days;
  - O/Os of a totally enclosed treatment facility;
  - O/Os of an elementary neutralization unit or a wastewater treatment unit (see definition in Part 264 standards, section 5 below);
  - a person engaged in treatment or containment activities during immediate response to a discharge; and
  - a transporter storing materials in containers meeting applicable requirements.

Permit Application Requirements for Existing Facilities

- **270.10(e)** - O/Os of existing facilities must submit a Part A permit application. Facilities that submit notification and Part A of the application are qualified for interim status.
- Part A applications must be submitted within 6 months of the final rule that removed the wastes from the Bevill exemption (by July 23, 1990).

Operating Requirements

- Requirements for interim status facilities are the same as for fully permitted facilities under Part 264 (see section 5) except in the following instances:
- For tank systems, O/Os must conduct a waste analysis whenever the waste treated in the tank is substantially different from the waste that was treated in the tank before. O/Os must perform trial treatment or show that existing treatment meets applicable requirements;
- For surface impoundments, O/Os must conduct a waste analysis whenever the waste treated in the surface impoundment is substantially different than was treated before or is being treated by a different process. O/Os must perform trial tests;
- For waste piles, O/Os must analyze a representative sample of incoming waste unless the wastes are compatible with wastes already being treated; and
- For land treatment, O/Os must:
    - determine the concentrations of substances that exceed the maximum concentrations contained in Table 1 of Part 261 that cause a waste to exhibit the EP toxicity characteristic;
    - if the waste is a listed hazardous waste, determine the concentrations of substances that caused the waste to be listed; and
    - if food chain crops are grown, determine the concentrations of arsenic, cadmium, lead, and mercury, unless the O/O can show that the constituents are not present.

5. Fully Permitted Facilities

Applicability

- Part 264 standards apply to all O/Os of facilities that treat, store, or dispose of hazardous waste except as specifically provided.
- Standards apply to persons who dispose of hazardous waste through ocean disposal subject to a permit under the Marine Protection, Research, and Sanctuaries Act only to the extent that they are included in a RCRA permit by rule.
- Standards apply to persons disposing of waste by underground injection subject to a permit issued under the Underground Injection Control program approved or promulgated under the Safe Drinking Water Act only to the extent that they are required by §144.14 of this chapter. (The Part 264 requirements do not apply to above-ground treatment or storage of hazardous waste before it is injected underground.)
- Standards **do not** apply to:
    - persons who treat, store, or dispose of wastes regulated by a State with a State authorized RCRA hazardous waste program;
    - O/Os of a facility permitted or licensed by a State to manage municipal or industrial solid waste if the only hazardous waste generated is exempted under the small quantity generator provision;
    - O/Os of a facility managing recyclable materials (261.6 (a)(2) and (3)); Recyclable materials include the following:

    - recyclable materials used in a manner constituting disposal;
    - recyclable materials from which precious metals are reclaimed;
    - scrap metal; and
    - coke and coal tar from the iron and steel industry that contains EPA hazardous waste K087.
  - a generator accumulating hazardous waste for less than 90 days;
  - O/Os of a totally enclosed treatment facility;
  - O/Os of an elementary neutralization unit (a tank, tank system, container, transport vehicle, or vessel that is used for neutralizing wastes that are hazardous only because they exhibit the corrosivity characteristic or they are listed in Part 261, Subpart D only because they exhibit the corrosivity characteristic) or is a wastewater treatment unit (a tank or tank system device that is part of a wastewater treatment facility subject to regulation under the Clean Water Act and receives, treats, or stores an influent hazardous wastewater; generates and accumulates a wastewater treatment sludge that is a hazardous waste; or treats or stores a wastewater treatment sludge that is a hazardous waste);
  - a person engaged in treatment or containment activities during immediate response to a discharge; and
  - a transporter storing materials in containers meeting applicable requirements.
- All O/Os that treat, store, or dispose of hazardous waste at a surface impoundment or a landfill that submit a Part B permit application after August 8, 1985, must provide information on the potential for the public to be exposed to hazardous waste/constituents through release from the facility.
- O/Os who have already submitted a Part B application must submit exposure information by August 8, 1985.

General Information Requirements for Part B Applications

- The following information is required for all hazardous waste management facilities:
  - **264.13(a)(1)** - Before an O/O treats, stores, or disposes of a waste he must obtain a detailed chemical and physical analysis of a sample of the waste. Analysis must contain all information necessary to treat, store, or dispose of the waste.
  - **264.13(a)(3)** - The analysis must be repeated as necessary to assure it is accurate and up to date.
  - **264.13(b)** - O/Os must develop a written waste analysis plan. The plan must contain: the parameters for each hazardous waste to be analyzed and a rationale for choosing the parameters; test methods used to test for the parameters; sampling methods used; the frequency of the review and repetition of the initial waste analysis; for off-site facilities, the analysis that the generators supply; any additional analysis required for ignitable, reactive, or incompatible wastes, bulk or containerized liquids, or wastes subject to the land disposal restrictions; and procedures and schedules for surface impoundments exempted from land disposal restrictions.
  - **264.14(a)** - the O/O must secure his facility to prevent unauthorized entry unless he can demonstrate physical contact with any of the equipment, waste, etc. will not cause injury and will not cause a violation of this subsection.

- **264.14(b)** - If the O/O is required to have security pursuant to § 264.14(a) above, he must have:
  - a 24-hour surveillance system or a barrier that will keep people out; and
  - a means to control entry at all times.
- **264.15(a)** - O/Os must inspect the facility for malfunctions and deteriorations, operator error, and discharges. Inspection must be often enough to correct any problems before they harm human health or the environment.
- **264.18(a)** - New facilities can not be located within 61 meters (200 feet) of a fault that has had movement of any two sides in Holocene time ("holocene" means the most recent epoch of the Quarternary period, extending from the end of the Pleistocene to the present).
- **264.18(b)** - A facility located in a 100-year floodplain must be designed to prevent washout of any hazardous waste by a 100-year flood. The O/O can avoid the design requirements if he can demonstrate to the Administrator that: 1) the facility has procedures that will remove hazardous wastes to a location where the wastes will not be touched by flood waters; or 2) for existing surface impoundments, waste piles, land treatment units, landfills, and miscellaneous units, no adverse effects on human health or the environment will result if washout occurs. Several factors must be considered, such as the volume and chemical characteristics of waste in the facility, the concentration of the hazardous constituents that may affect surface water, the impact of the constituents on users of the water and on water quality standards, and the impact of the constituents on soil.
- **264.18(c)** - No non-containerized or bulk liquid hazardous waste can be placed in any salt dome formation, salt bed formation, underground mine or cave, with the exception of the Department of Energy Waste Isolation Pilot Project in New Mexico.
- **264.112** - O/Os of hazardous waste management facilities must have a written closure plan. The closure plan must:
  - describe how each management facility will be closed;
  - give an estimate of the types of wastes at the facility; the methods for removing, transporting, treating, storing, or disposing wastes; and an identification of the off-site facilities to which the wastes will go;
  - describe steps to remove and decontaminate all hazardous waste residues, equipment, containment system components, and soils;
  - describe all ground-water monitoring, leachate collection, and run-on and run-off control; and
  - include a schedule for closure.
- **264.118** - A copy of the post-closure plan. The plan required for hazardous waste management facilities must include:
  - a description of the monitoring and maintenance activities that will be performed to ensure the integrity of the cap and final cover or other containment system, and the functioning of the remaining monitoring equipment.
- **264.178** - At closure, all hazardous waste and hazardous waste residue must be removed from all containment systems. Remaining containers, liners, bases, and soil containing hazardous constituents must be decontaminated or removed.

- **264.197** - Closure and post-closure care requirements for tank systems: remove or decontaminate all waste residues, equipment, and tanks. If the O/O can demonstrate that it is not practicable to remove or decontaminate all contaminated soils, the O/O must close and perform post-closure care in accordance with the requirements that apply to a landfill (see §264.310 below).
- **264.228** - Closure and post-closure care requirements for surface impoundments. The O/O must:
  a) remove or decontaminate all waste residues, contaminated containers, soils, and equipment; or
  b) eliminate free liquids; stabilize remaining wastes to a capacity to support final cover; and cover the surface impoundment with a final cover that will minimize long-term liquids migration, require minimal maintenance, promote drainage and minimize erosion of the cover, accommodate settling or subsidence so that the cover's integrity is maintained, and have a permeability less than or equal to the permeability of any bottom liner system or natural soils present.
- **264.258** - Closure and post-closure care for waste piles. O/Os must:
  - remove or decontaminate all waste residues, contaminated containers, soils, and equipment;
  - if there are hazardous constituents that can not be practicably removed or treated, the O/O must close the facility as if it were a landfill (see § 264.310 below); and
  - if a waste pile that does not have a liner designed to minimize migration of wastes, the O/O must prepare a contingent closure plan in case not all of the hazardous constituents can be removed.
- **264.280** - Closure and post-closure care for land treatment facilities. O/Os must:
  - continue operations that degrade, transform, or immobilize hazardous waste constituents within the treatment zone;
  - continue operations to minimize run-off of hazardous constituents;
  - maintain run-on control system;
  - maintain run-off management system;
  - control wind dispersal of hazardous constituents;
  - continue unsaturated zone monitoring; and
  - plant vegetative cover on the area being closed.
- **264.310** - Closure and post-closure care requirements for landfills. O/Os must cover the landfill with a cover that:
  - provides long-term minimization of liquid migration through the closed landfill;
  - requires little maintenance;
  - accommodates settling and subsidence so that the cover's integrity is maintained; and
  - has a permeability of less than or equal to the permeability of any bottom liner system or natural subsoils present.

- During the post-closure care period the O/O must:
  - maintain the final cover;
  - continue leachate collection and removal;
  - maintain ground-water monitoring; and
  - prevent run-on and run-off from eroding or damaging the final cover.
- **264.142** - O/Os must have a detailed written estimate, in current dollars, of the cost of closing the facility.
- **264.143** - All O/Os, except those exempted under §264.1, must establish financial assurance for closure for each facility.
- **264.144** - O/Os of a disposal surface impoundment, disposal miscellaneous unit, land treatment unit, landfill unit, or a surface impoundment or waste pile required to prepare a contingent closure and post-closure plan, must have a detailed written estimate of the annual cost of closure and post-closure care.
- **264.145** - All O/Os that must submit a contingent closure and post-closure plan must establish financial assurance for the post-closure care.
- **264.147(a)** - O/Os of a TSD facility, or a group of facilities, must demonstrate financial responsibility for bodily injury and property damage to third parties caused by sudden accidental occurrences arising from the operation of the facility in the amount of at least $1 million per occurrence with an annual aggregate of at least $2 million.
- **264.147(b)** - O/Os of a surface impoundment, landfill, or land treatment facility that is used to manage hazardous waste, or a group of facilities, must demonstrate financial responsibility for bodily injury and property damage to third parties caused by non-sudden accidental occurrences arising from the operation of the facility in the amount of at least $3 million per occurrence with an annual aggregate of at least $6 million. O/Os may combine the per-occurrence coverage levels for sudden and non-sudden occurrences into a single per-occurrence level, and may combine the annual aggregate coverage levels for sudden and non-sudden occurrences into a single annual aggregate level.
- **270.14(b)(19)** - O/Os must prepare a topographic map showing the distance of 1000 feet around the facility at a scale of 2.5 centimeters (1 inch) equal to not more than 61.0 meters (200 feet).
- **270.14(c)** - Additional ground-water protection information. O/Os must:
  - provide a summary of the ground-water monitoring data obtained during the interim status period;
  - identify the uppermost aquifer and aquifers hydraulically interconnected beneath the facility property. Must include ground-water flow direction and rate, and the basis for this information;
  - provide, on the topographic map required under § 270.14(b)(19), a delineation of the waste management area, the property boundary, the proposed point of compliance, the proposed location of the ground-water monitoring wells, and the aquifer information required under § 270.14(c)(2);
  - provide a description of any plume of contamination that has entered ground water; and
  - prepare plans and engineering reports of the proposed ground-water monitoring system and detection monitoring program.

  - if hazardous constituents have not been detected in the ground water at the time of permit application, the O/O must submit information, data, and analyses to establish a detection monitoring system.
  - if hazardous constituents have been detected in the ground water at the point of compliance, the O/O must submit information, data, and analyses to establish a compliance monitoring system.
  - if hazardous constituents have been measured in the ground water that exceed the maximum concentration limits, or if ground-water monitoring at the waste boundary indicates that hazardous constituents from the facility are present over background levels, the O/O must submit information, data, and analyses to establish a corrective action program.

6. SUBPART C - Specific Requirements for Preparedness and Prevention

- **264.31** - Facilities must be designed to minimize fire, explosion, or release of wastes.
- **264.32** - Facilities must be equipped with:
  - an internal communications or alarm system;
  - a device to summon emergency assistance;
  - portable fire extinguishers; and
  - water to supply hoses or an automatic sprinkler system.
- **264.33** - All equipment listed above must be maintained and tested.

7. SUBPART F - Particular Standards for Releases From Solid Waste Management Units

- **264.90(b)** - An O/O's regulated units are not subject to the requirements under this section if:
  - exempt under 264.1; or
  - the Regional Administrator finds that he operates a unit that:
    - is an engineered structure that does not receive or contain liquid waste or waste containing free liquid;
    - is designed and operated to exclude liquid, precipitation, and other run-on and run-off;
    - has both inner and outer layers of containment enclosing the waste;
    - has a leak detection system built into each containment layer;
    - the leak detection system will be continually operated and maintained during the active life of the facility and during closure and post-closure care; and
    - the system will not, to a reasonable degree of certainty, allow hazardous constituents to migrate beyond the outer containment area.
  - the Regional Administrator finds that the treatment zone of a land treatment unit does not contain levels of hazardous constituents that are above background levels by an amount that is statistically significant, and if an unsaturated zone monitoring program (see § 264.278) has not shown a statistically significant increase in hazardous constituents below the treatment zone during the operating

    life of the unit. An exemption under this paragraph can only exempt an O/O from the requirements of this Subpart during the post-closure care period;

  - the Regional Administrator determines that there is no potential for migration of liquid to the uppermost aquifer during the active life of the regulated unit including the closure period and during the post-closure care period. A certified geologist or geotechnical engineer must certify this; or
  - the O/O operates a waste pile that is inside or under a protective cover that provides protection from precipitation.

- **264.91(a)** - O/Os must conduct a monitoring and response program (the Regional Administrator specifies the elements of each applicable program in the facility permit) as follows:
  - whenever a hazardous constituent is detected at a statistically significant level at a compliance point the O/O must institute a compliance monitoring system pursuant to § 264.99;
  - whenever the ground-water standard is exceeded by a statistically significant amount the O/O must complete a corrective action program pursuant to § 264.100;
  - whenever hazardous constituents from a regulated unit exceed the concentration limits between the compliance point and the downgradient facility property the O/O must complete a corrective action program; and
  - in all other cases, O/Os must institute a detection monitoring program that monitors waste constituents pursuant to § 264.98.

All ground-water monitoring systems must comply with the requirements in § 264.97 including:

- **264.97(a)** - A ground-water monitoring system must have a sufficient number of wells at appropriate locations and depths to yield samples from the uppermost aquifer that represent: 1) the quality of background water that has not been affected by leakage from a regulated unit; and 2) the quality of ground water passing the point of compliance.
- **264.97(b)** - If a facility contains more than one regulated unit, separate ground-water monitoring systems are not needed for each unit so long as the systems ensure detection and measurement at the compliance point of hazardous constituents from the regulated units.
- **264.97(c)** - All monitoring wells must be cased so as to maintain the integrity of the monitoring bore hole.

Sections 264.98, 264.99, and 264.100 impose specific requirements for detection monitoring, compliance monitoring, and corrective action monitoring systems in addition to the general requirements specified in § 264.97. These requirements include:

- **264.98(c)** - O/Os must establish and maintain an approved ground-water monitoring detection system for each chemical parameter and each chemical constituent specified in the facility permit.
- **264.99(a)-(e)** - O/Os who are required to establish a compliance monitoring program must: monitor the ground water to determine whether the regulated units are in compliance with the ground-water protection standard specified in § 264.92; install a ground-water monitoring system at the compliance point; determine whether there is statistically significant evidence of increased contamination for any chemical parameter

or hazardous constituent specified in the permit; and at least annually, determine the ground-water flow rate and direction of the uppermost aquifer.

- **264.100(a)** - O/Os must take corrective action to ensure that regulated units are in compliance with the ground-water protection standard in the facility permit.
- **264.100(b)** - O/Os must institute an approved corrective action program that prevents hazardous constituents from exceeding their concentration limits by removing the hazardous waste constituents or treating them in place.
- **264.100(d)** - O/Os must implement an approved ground-water monitoring program to demonstrate the effectiveness of the corrective action program.
- **264.101(a)** - O/Os seeking a permit for a TSD facility must institute an approved corrective action program as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit.

8. SUBPART G - Closure and Post-Closure

- **264.111(a) - (c)** - O/Os must close the facility in a manner that: 1) minimizes the need for further maintenance; 2) controls and minimizes post-closure escape of hazardous waste, run-off, or hazardous waste decomposition products to ground and surface water and to the atmosphere; and 3) complies with all closure requirements.
- **264.114** - All contaminated equipment and soils from partial and final closure must be properly disposed of or decontaminated.
- **264.117** - Post-closure care must begin after completion of closure and must continue for 30 years.

9. SUBPART I - Specific Requirements for Use and Management of Containers

- **264.172** - O/Os must use a container made of or lined with material that will not react with the hazardous waste to be stored in the container.
- **264.175(b)** - A containment system must have the following:
    - a base underlying the container that is free of cracks and is impervious so as to contain leaks and spills until collected;
    - a base that is sloped or a containment system designed so that liquids from leaks can be drained and removed;
    - sufficient capacity to contain 10 percent of the volume of containers or the volume of the largest container, whichever is greater. Containers that do not contain free liquids do not have to follow this requirement; and
    - a method of preventing run-on into the containment system unless the system has sufficient excess capacity to contain the run-on. Spilled or leaked waste must be removed from the sump or collection area to prevent overflow.

10. SUBPART J - Specific Requirements for Tank Systems

- The requirements of this section do not apply to tank systems that do not contain free liquids and are inside a building with an impermeable floor, a tank systems, including sumps, that are part of a secondary containment system.
- **264.191** - For each existing tank system that does not have secondary containment, O/Os must assess the tank system to determine whether it is adequately designed and is structurally sufficient to store waste. Minimum requirements for assessment are provided. Requirements include assessment of the design, assessment of the tank, material used, and components of external shell.
- **264.192** - O/Os of new tank systems must submit to the Regional Administrator, with the submittal of Part B application information, a written assessment, reviewed and certified by an independent, qualified registered professional engineer, attesting that the tank system has sufficient structural integrity and is acceptable for storing waste.
- **264.193** - Secondary containment must be provided for:
  - all new tank systems and components prior to being put into service;
  - existing tank systems for which the age cannot be determined, within two years of January 12, 1987 or when the tank system has reached 15 years of age, whichever comes later;
  - existing tank systems for which the age cannot be determined, within eight years of January 12, 1987; if the age of the facility is greater than seven years, secondary containment must be provided by the time the facility reaches 15 years of age, or within two years of January 12, 1987, whichever comes later; and
  - tank systems that store or treat materials that become hazardous wastes after January 12, 1987, within the time intervals required by the preceding paragraphs, except that the date that a material becomes a hazardous waste must be used in place of January 12, 1987.
- **264.193(c)** - Specifies the following construction requirements for secondary containment systems that must be met:
  - constructed of or lined with material that is compatible with the waste that will go inside the tank;
  - placed on a foundation or base capable of supporting the system, resistant to pressure gradients above and below the system, and capable of preventing failure due to settlement, compression, or uplift;
  - provided with a leak-detection system designed so that it will detect failures of the system within 24 hours, or within the earliest practicable time if the O/O can demonstrate that existing detection systems will not allow detection within 24 hours; and
  - sloped or otherwise designed or operated to drain and remove liquids that leak or spill.
- **264.193(d)** - Secondary containment for tanks must include one of more of the following:
  - a liner external to the tank;
  - a vault;

  - a double-walled tank; or
  - an equivalent device approved by the Regional Administrator.
- **264.196** - Requirements for response to leaks: prevent flow or addition of wastes; remove waste from tank; contain visible release; and provide secondary containment.

11. SUBPART K - Specific Requirements for Surface Impoundments

- **264.221(a)** - Existing surface impoundments must have a liner that is designed, constructed, and installed to prevent any migration of wastes to the subsurface soil or surface and ground water for the active life, including the closure period, of the impoundment. The liner may allow wastes to migrate into the liner.
- **264.221(b)** - An O/O can be exempted from design requirements if he can show that an alternative design will prevent migration of wastes.
- **264.221(c)** - Each new surface impoundment, each new surface impoundment at an existing facility, and each replacement of an existing surface impoundment must have two or more liners and a leachate collection system between the liners.
- **264.228** - Closure and post-closure care requirements. (See section 5 above.)
- **264.230** - Incompatible wastes must not be placed in the same surface impoundment.

12. SUBPART L - Specific Requirements for Waste Piles

- **264.250(a)** - Regulations apply to O/Os of facilities that treat, store, or dispose of wastes in waste piles.
- **264.250(b)** - The regulations do not apply to O/Os of waste piles that are closed with wastes left in place; these waste piles are regulated as landfills. The regulations do not apply to O/Os of waste piles that are inside or are protected from precipitation provided that:
  - liquids or materials containing free liquids are not placed in the pile;
  - the pile is protected from surface water run-on;
  - the pile is designed and operated to control dispersal of the waste by wind or means other than by water; and
  - the pile will not generate leachate through decomposition.
- **264.251(a)** - A waste pile must have:
  - a liner that prevents migration of any wastes out of the pile into adjacent subsurface soil and surface and ground water during the active life of the pile, including the closure period. The liner may allow wastes to migrate into the liner itself; and
  - a leachate collection and removal system above the liner.
- **264.251(b)** - An O/O can be exempted from design requirements if he can show that an alternative design will prevent migration of wastes.
- **264.251(c)** - O/Os must design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the pile during peak discharge from at least a 25-year storm.
- **264.251(d)** - O/Os must design, construct, operate, and maintain a run-off management system to collect and control water volume resulting from a 24-hour, 25-year storm.

- **264.251(f)** - Any particulate matter subject to wind dispersal must be covered.
- **264.257** - Incompatible wastes must not be placed in the same waste pile.
- **264.258** - Closure and post-closure care requirements. (See section 5 above)

13. SUBPART M - Specific Requirements for Land Treatment

- **264.271(a)** - O/Os who use land treatment must establish a program designed to ensure that hazardous constituents placed in or on the treatment zone are degraded, transformed, or immobilized within the treatment zone. The Regional Administrator will specify in the permit the requirements of the program.
- **264.271(c)** - The Regional Administrator will specify the vertical and horizontal dimensions of the treatment zone. The maximum depth of the treatment zone must be no more than 1.5 meters (5 feet) from the initial surface soil and more than 1 meter (3 feet) above the seasonal high water table.
- **264.272(a)** - Before applying the waste to the treatment zone, the O/O must demonstrate, for each waste, that the hazardous constituents in the waste will be completely degraded, transformed, or immobilized in the treatment zone.
- **264.272(b)** - In performing the demonstration, the O/O can use field tests (must obtain a treatment and disposal permit), laboratory analysis, available data, or operating data if an existing facility.
- **264.273(a)** - O/Os must design and operate a facility in accordance with all of the operating conditions that were used in the demonstration.
- **264.273(b)** - O/Os must design, construct, operate. and maintain the treatment zone to minimize run-off of hazardous constituents.
- **264.273(c)** - O/Os must design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the pile during peak discharge from at least a 25-year storm.
- **264.273(d)** - O/Os must design, construct, operate, and maintain a run-off management system to collect and control water volume resulting from a 24-hour, 25-year storm.
- **264.273(f)** - Any particulate matter subject to wind dispersal must be covered.
- **264.276(a)** - Food-chain crops can be grown on land treatment zones if the O/O can demonstrate that there is no substantial risk to human health caused by the growth of the crops on the zone. The demonstration must show that the hazardous constituents (other than cadmium) will not be transferred to the plants by plant uptake, or will not occur in concentrations greater than those found in the same plants not grown in treated soil.
- **264.276(a)(3)** - This demonstration can be made through field tests, greenhouse studies, available data, or operating data for existing facilities.
- **264.276(a)(4)** - O/Os must obtain a permit for field and greenhouse testing.
- **264.276(b)** - If cadmium is contained in the waste, the following conditions apply:
    - the pH of the waste and soil mixture must be 6.5 or greater at the time of each waste application, except for waste containing cadmium at concentrations of 2 mg/kg (dry weight) or less;

  - the annual application of cadmium from waste must not exceed 0.5 kilograms per hectare (kg/ha) on land used for tobacco, leafy vegetables, or root crops grown for human consumption. For other food-chain crops the annual application rate must not exceed 0.5 kg/ha beginning January 1, 1987;
  - the cumulative application of cadmium must not exceed 5 kg/ha if the waste and soil mixture has a pH of less than 6.5; and
  - if the pH is 6.5 or greater or is maintained at a pH of 6.5 or greater during crop growth, the cumulative application must not exceed 5 kg/ha if soil cation exchange capacity (CEC) is less than 5 meq/100g; 10 kg/ha if CEC is 5-15 meq/100g; and 21 kg/ha if CEC is greater than 15 meq/100g.
- **264.276(b)(2)** - If animal feed is the only crop produced, the pH must be 6.5 or greater at the time of waste application or at the time the crop is planted, whichever is later. This pH level must be maintained during crop growth.
- **264.276(b)(2)(iii)** - A plan must be prepared showing how the crop will be distributed to assure that the crop is not consumed by humans.
- **264.278(a)** - O/Os must monitor the soil and soil-pore liquid to determine whether hazardous constituents have migrated out of the treatment zone.
- **264.280** - Closure and post-closure care requirements. (See section 5 above)

14. SUBPART N - Specific Requirements for Landfills

- **264.301(a)** - All existing landfills must have a liner system for all portions of the landfill. The liner system must:
  - have a liner that prevents any migration of wastes to adjacent subsurface soil and surface and ground water during the active life of the landfill, including the closure period. The liner must prevent wastes from passing into the liner itself; and
  - have a leachate collection system above the liner.
- **264.301(b)** - An O/O can be exempted from the design requirements if he can show that an alternative design prevents migration of wastes.
- **264.301(c)** - O/Os of a new landfill, a new landfill unit at an existing facility, a replacement of an existing landfill unit, or a lateral expansion of an existing landfill unit, must install two or more liners and a leachate collection system above and between the liners. An O/O can satisfy the requirements of this section by installing a top liner that prevents migration of any constituent into the liner and a lower liner that prevents migration of constituents through the liner.
- **264.301(d)** - The double liner requirement will not apply if the O/O can demonstrate that an alternative design will prevent the migration of any hazardous constituents into the ground water.
- **264.301(f)** - The landfill must have a run-on control system capable of preventing flow from at least a 25-year storm onto the active portion of the pile during peak discharge.
- **264.301(g)** - The landfill must have a run-off management system to collect and control water volume resulting from a 24-hour, 25-year storm.
- **264.301(h)** - Collection and holding facilities for run-on and run-off control systems must be emptied after storms.
- **264.301(i)** - Any particulate matter subject to wind dispersal must be covered.

- **264.310** - Closure and post-closure care requirements. (See section 5 above)
- **264.314(b)** - Effective May 8, 1985, bulk or non-containerized liquid hazardous waste cannot be placed in a landfill.
- **264.314(c)** - O/Os must perform a test to demonstrate the absence or presence of free liquids in either bulk or containerized waste.
- **264.314(e)** - Effective November 8, 1985, no liquids can be placed in a landfill unless the Regional Administrator determines that:
  - the only other alternative is placement in a landfill or an unlined surface impoundment that contains hazardous waste; and
  - placement in the landfill will not contaminate ground water.

15. PART 268 - Land Disposal Restrictions

- In the final rule for the Third Third land disposal restrictions (LDRs), EPA classified mineral processing wastes that have been taken out of the Bevill exemption as "newly identified" wastes. Consequently, BDAT for mineral processing wastes that exhibit hazardous characteristics (e.g., corrosivity, EP toxicity) will not apply, even if these wastes are removed from the Mining Waste Exclusion until EPA, by separate rulemaking, establishes standards for these wastes under §3004(g)(4). Nonetheless, when newly identified wastes are mixed with other prohibited waste, the newly identified wastes are subject to existing hazardous waste prohibitions.

Appendix E-2

Subtitle D-Plus Regulatory Program Scenario

Appendix E-2

Subtitle D-Plus Regulatory Program Scenario

This regulatory scenario constitutes one possible approach to a RCRA Subtitle D program for some or all special wastes from mineral processing that remain within the Mining Waste Exclusion. The approach described here has been developed solely for analytical purposes by staff of EPA's Special Wastes Branch of the Office of Solid Waste, and is tailored to address some of the special characteristics of mineral processing wastes. The reason for inclusion of a Subtitle D scenario in this report is that the Agency is presently developing a tailored program to address mineral extraction and beneficiation wastes under Subtitle D (referred to herein as a "D-Plus" program), and would consider applying this program to any of the 20 mineral processing wastes subject to this study that remain excluded from regulation under RCRA Subtitle C after the regulatory determination that will follow, and be based upon, this report. The following presents a summary discussion of the scope and various requirements of the RCRA Subtitle D-Plus program scenario crafted for use in this Report to Congress.

Applicability and Permits

- Owners/operators of existing units must be in compliance with all applicable provisions of the rule by the compliance date established by the regulatory authority (i.e., a state with an approved program or EPA when implementing a state program), which may be no later than five years following EPA approval of the state mining waste management plan or the federal implementation of a state plan. Because states will have up to roughly three and one-half years to develop a mining waste program, the compliance date could fall anywhere from roughly six to nine years after the promulgation of the federal rule, with eight years following federal promulgation being a reasonable average.
- New units (i.e., units that begin receiving waste after the compliance date) must be in compliance upon the initiation of activity.
- Compliance entails meeting all technical criteria, having completed all appropriate plans and assessments (e.g., closure plans), and having all required permits in place. All requirements are unit-specific.

Waste Characterization

- Owners/operators of all existing and new units must perform, for each unit, a characterization of the regulated wastes currently or to be managed in the unit, and must update that characterization at least once every five years. This characterization must include:
    - A total constituent analysis, using SW-846 or equivalent methods, for arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver (i.e., TC metals listed at 40 CFR § 261.24 Table 1);
    - A total constituent analysis for radionuclides;
    - A total constituent analysis for any other parameters identified by the state;
    - A measure of acid generation potential;
    - A quantitative assessment of the potential variability in the composition of the regulated material being managed;
    - A minimum site characterization (e.g., environmental setting, climate, land/natural resource setting); and
    - A description of the characterization protocols used by the owner/operator.

- Based on these analyses, the owner/operator must identify any and all "parameters of concern" present in the unit. ("Parameter of concern" is not clearly defined, but most likely will be defined either explicitly or de facto to include any TC metal present in a measurable concentration and any other parameter, such as pH, existing in a manner likely to pose an environmental risk).

Performance Standards

- If one or more parameters of concern are identified for a given unit, the regulatory authority must establish performance standards for those parameters. In order to establish performance standards, owners/operators must assess the potential for releases of any of the parameters of concern from the unit to the environment via ground water, surface water, air, or soils and surficial materials. The regulatory authority may waive the requirement for establishing surface water performance standards if the owner/operator demonstrates that the concentration of the parameter of concern in the regulated unit could not result in a discharge exceeding the potential performance standard. The regulatory authority may waive the requirement for establishing air or soils/surficial materials performance standards if the owner/operator demonstrates that the management practices being performed eliminate the potential for release to these media.

- The rule establishes methodologies that the regulatory authority must follow in developing ground water, surface water, air, and soils and surficial materials performance standards. These methodologies give precedent to established state numeric standards (which must be at least as stringent as corresponding federal standards), followed by federal numeric standards (i.e., MCLs), and finally site-specific risk-based standards. In all cases, if background concentrations exceed the applicable numeric standard then background becomes the performance standard. The point of compliance generally is no further than the actual or anticipated unit boundary.

Design and Operating Criteria

- Owners/operators of all existing and new units containing one or more parameters of concern for which performance standards were established must comply with both general and, if relevant, site-specific design and operating criteria. Actual design and operating criteria requirements are left largely to the discretion of the regulatory authority.

- The general criteria require that owners/operators ensure "the continued structural stability of (the unit), and that releases from (the unit) that exceed performance standards and/or catastrophic failure do not occur." Structural stability must be maintained throughout the unit's entire active, closure, and post-closure care periods. Owners/operators also must control human and wildlife access to, and contact with, regulated materials that might pose a human health or environmental risk. Owners/operators are prohibited from disposing of RCRA hazardous wastes in the regulated unit. In addition to these mandates and prohibitions, the general criteria require that owners/operators institute a run-on/run-off control system such that run-off from the unit will not cause a discharge of pollutants to waters of the U.S. This run-on/run-off control system also must be placed in a configuration at closure that allows for restoration of the natural drainage network to the extent practicable.

- The general design and operating provisions of the rule also contain unit-specific criteria as follows:
    - Existing surface impoundments must maintain sufficient freeboard to prevent overtopping;
    - New surface impoundments must be designed to prevent overtopping;
    - Land application of regulated materials as soil amendments cannot begin until the owner/operator assesses potential threats to human health and the environment from potential releases and human contact (i.e., performance standard exceedances), establishes a plan detailing application rates, and provides for periodic sampling of the applied materials; and

  - Land application of regulated materials as a treatment process can take place only after the owner/operator completes a soil and surficial material protection plan that incorporates, as necessary, vadose zone monitoring, periodic measures of the soil treatment zone depth, a characterization of the uppermost aquifer, test plots to monitor migration, measurements of soil loadings of pollutants, and periodic reports.

- Finally, the general design and operating provisions require that owners/operators submit information and take steps necessary to ensure the protection of biological resources, including unit access control, as necessary, and compliance with the Endangered Species Act of 1973.

- In addition to these general criteria, units located in certain sensitive areas (as defined by the rule) must meet location-specific design and operating criteria that are intended to ensure that releases do not occur in exceedance of performance standards. These criteria are as follows:
  - FLOODPLAINS (100 year) - Owners/operators must assess the effect of the unit on the restriction of flow of surface waters, the reduction or temporary loss of water storage and conductance capacity in the floodplain, and the potential for washout of regulated materials and resulting contaminant releases. The regulatory authority may require modifications to existing units, or design plans for new units, as necessary to protect human health and the environment, based on the owner/operator's assessment.
  - WETLANDS - Units located in wetlands (as defined by the rule) must comply with all applicable CWA § 404 provisions and provisions of the Marine Protection, Research and Sanctuaries Act of 1972. The regulatory authority may require modifications to new or existing units in order to ensure that performance standards are met.
  - SEISMIC IMPACT ZONE (i.e., any area where the probability is greater than or equal to 10 percent that the maximum horizontal acceleration in lithified earth material will equal or exceed 0.20 g in 50 years) - Owners/operators of existing units may be required to modify the design and/or to implement operating requirements necessary to ensure structural stability at the discretion of the regulatory authority. Owners/operators of new units containing regulated materials with high moisture contents must design, construct, and operate those units to withstand the maximum horizontal acceleration from seismic impacts during operation. Other new units must be designed, constructed, and operated to ensure structural stability.
  - UNSTABLE AREAS (e.g., areas with landslide potential or in the path of potential rock slides or avalanches) - Owners/operators of existing units may be required to modify the design and/or to implement operating requirements necessary to ensure structural stability at the discretion of the regulatory authority. Owners/operators of new units must demonstrate that the proposed design of the unit is adequate to ensure the stability of all structural components of the unit during operation, closure, and post-closure care.
  - FAULT AREAS (i.e., within 61 meters of a fault having had displacement within Holocene time) - Owners/operators of existing units may be required to modify the design and/or to implement operating requirements necessary to ensure structural stability at the discretion of the regulatory authority. Owners/operators of new units must demonstrate that any movement along the fault and in the adjacent zone of deformation will not disrupt the contents of the unit or damage the structural stability of the unit such that applicable performance standards would be exceeded.
  - KARST TERRANE (i.e., areas where karst topography exists as the result of dissolution of limestone, dolomite, or other soluble rock) - Owners/operators of new and existing units must demonstrate that performance standards for ground and surface water will be met during construction, operation, closure, and post-closure care. At the discretion of the regulatory authority, owners/operators must undertake a study that: 1) demonstrates, based on hydrogeologic analyses, that the unit(s) is in fact within a Karst Terrane; 2) characterizes the degree of stability and potential subsidence of the unit(s) based on the historical changes in regional and local water levels and on the history and presence of sinkhole development during Holocene time; and 3) demonstrates, based on engineering analysis, that the unit will not lose its structural stability.

authority may require the modification of existing units, or the modification of new unit plans, at its discretion based on the owner/operator's analyses.

- PERMAFROST (i.e., areas where water within surface and subsurface material persists in a frozen or partially frozen state throughout the year) - Owners/operators of existing units underlain by permafrost may be required to modify the design and/or to implement operating requirements necessary to ensure structural stability at the discretion of the regulatory authority. Owners/operators of new units underlain by permafrost must design, construct, and operate those units to ensure structural stability.
- WELLHEAD PROTECTION AREAS (i.e., areas surrounding public water supply wells) - Owners/operators must conduct a study to determine whether the regulated unit is in fact within a wellhead protection area, as defined by state or federal criteria. If the regulated unit is within a wellhead protection area, the regulatory authority may require the modification of existing units, or the plans for new units, to ensure that contaminants for which performance standards were established will not be released.

Monitoring

- Most of the monitoring requirements under this regulatory approach are media-specific, addressing ground water, surface water, air, and soils and surficial materials. For each of these media, the owner/operator must perform an assessment of the potential for releases of parameters of concern from the regulated unit, other than surface water discharges permitted under § 402 of the Clean Water Act or air emissions authorized under the Clean Air Act. The regulatory authority may then exempt an owner/operator from monitoring a given medium for a given parameter if, based on the owner/operator's assessment, the regulatory authority determines that there will be no release from the unit exceeding that parameter's performance standard for the medium. For any parameters of concern not exempted from monitoring, the owner/operator must establish a monitoring system that is capable of characterizing the background quality of the medium and the extent of contamination, if any, caused by a release. The media-specific technical monitoring criteria are summarized below.

- GROUND WATER - For any parameters of concern not exempted by the regulatory authority from ground-water monitoring, the owner/operator must establish a ground-water monitoring system that is capable of characterizing any release of those parameters of concern from the unit in violation of respective performance standards. This ground-water monitoring system must comply with a ground-water monitoring plan that considers the hydrogeologic setting, number and placement of wells, and the sampling protocol necessary to adequately characterize background water quality and water quality at the point of compliance. The owner/operator also must indicate what protocols and statistical methods will be used to determine that an exceedance of a performance standard has occurred. If the exceedance of a performance standard is detected and verified, the owner/operator must undertake a corrective action plan (as described below).

- SURFACE WATER - The emphasis of this regulatory approach is to promote the adoption of management practices allowing the waiver of monitoring of surface water in lieu of the establishment of a surface-water monitoring system. Nonetheless, for any parameters of concern not exempted by the regulatory authority from surface water monitoring, the owner/operator must establish a surface water monitoring system that is capable of characterizing any release of those parameters of concern from the unit in violation of the respective performance standards. This surface water monitoring system must adopt protocols necessary to ensure the accurate characterization of the receiving surface water quality (i.e., background) and the quality of discharges from the unit. Sampling must be undertaken at least quarterly. If the exceedance of a performance standard is detected and verified, the owner/operator must undertake a corrective action plan (as described below).

- AIR - The emphasis of this regulatory approach is to promote the adoption of management practices allowing the waiver of monitoring of air in lieu of the establishment of an air monitoring system. Nonetheless, for any parameters of concern not exempted by the regulatory authority from air monitoring, the owner/operator must establish an air monitoring system that is capable of characterizing any release of those parameters of concern from the unit in violation of the respective performance standards. This air monitoring system must adopt protocols necessary to ensure the accurate characterization of the background air quality (as measured at an upwind point specified by the regulatory authority) and the concentration of parameters of concern at the point of compliance. The point of compliance for air emissions under this regulatory approach generally will be the facility boundary. Sampling must be undertaken at least quarterly. If the exceedance of a performance standard is detected and verified, the owner/operator must undertake a corrective action plan (as described below).

- SOILS AND SURFICIAL MATERIALS - The emphasis of this regulatory approach is to promote the adoption of management practices allowing the waiver of monitoring of soils and surficial materials in lieu of the establishment of a soils/surficial materials monitoring system. Nonetheless, for any parameters of concern not exempted by the regulatory authority from soils/surficial materials monitoring, the owner/operator must establish a soils/surficial materials monitoring system that is capable of characterizing any potential release of those parameters of concern from the unit in violation of respective performance standards. This soils/surficial materials monitoring program must adopt protocols necessary to ensure the accurate characterization of the concentrations of parameters of concern in native soils samples and the concentration of parameters of concern at the point of compliance. Sampling must be undertaken at least quarterly. If the exceedance of a performance standard is detected and verified, the owner/operator must undertake a corrective action plan (as described below).

- In addition to these media-specific monitoring criteria, owners/operators must comply with provisions for the verification of design and operating criteria. The regulatory authority must specify protocols for the inspection of units by qualified professionals in order to ensure continued compliance with all applicable design and operating criteria during operational, closure, and post-closure care periods. If the regulatory authority determines and verifies that one or more of the applicable design and operating criteria have been violated, the owner/operator must undertake a corrective action plan.

Corrective Action

- If, based on the results of the monitoring activities required above, the regulatory authority determines that one or more performance standards have been exceeded at a regulated unit,[1] the owner/operator must undertake corrective action. The owner/operator's corrective action activities must follow an approved corrective action plan that 1) is protective of human health and the environment, 2) proposes a remedy that controls the source(s) of release and ensures compliance with the performance standard(s), and 3) proposes a schedule for initiating and completing corrective action. This corrective action plan must be completed within one year of the determination of exceedance.

- If, based on the results of the verification requirements for design and operating criteria compliance as described above, any defects in a regulated unit are found, or if the unit is not in compliance with the design and operating criteria for some other reason (e.g., structural failure), then the owner/operator must submit a corrective action plan that 1) ensures protection of human health and the environment, 2) provides a remedy that ensures compliance with applicable design and operating criteria throughout operation, closure, and post-closure care, and 3) specifies a schedule for initiating and completing corrective action. In developing the plan, the owner/operator must consider the extent and potential impacts of non-compliance; the capability of the selected remedy to achieve compliance; and other relevant factors specified by the regulatory authority. Once the correction action plan is approved by the regulatory authority, the owner/operator must complete corrective action according to the plan.

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[1] Unlike the RCRA Subtitle C program, corrective action for solid waste management units other than regulated units would not be required under this scenario.

Closure/Post-Closure Care

- The purpose of closure and post-closure care is to ensure the continued structural stability of the unit and integrity of systems designed to ensure compliance with all performance standards and design and operating criteria. To this end, all units must continue to comply with all applicable design and operating criteria, monitoring criteria, and corrective action requirements throughout the closure and post-closure care periods.
- Closure must include a final regulated materials characterization and may entail further the removal of all regulated materials from the unit, actions to neutralize or immobilize parameters of concern, or other actions necessary to ensure permanent compliance with applicable performance standards and design and operating criteria (e.g., structural stability). If regulated materials remain in the unit, the owner/operator must add a notation to the property deed indicating the presence of the material, what it consists of and what parameters of concern are present, and the anticipated post-closure land use for the area.
- An owner/operator must conduct closure in accordance with the closure plan, which must be completed and approved prior to the receipt or management of regulated materials, for the unit(s) in question. The closure plan must include a description of the activities necessary to ensure adequate closure at any point during the life of the unit, addressing continued compliance with performance standards, continued structural stability, access control, and any other relevant design and operating criteria. The closure plan also must be certified by a qualified professional (as defined by the rule) and must be established as part of an enforceable permit.
- Closure is triggered by 24 months of inactivity and must be completed within five years of the initiation of closure activities.
- Owners/operators must conduct post-closure care for all units in which regulated materials are present, unless the owner/operator demonstrates that ongoing maintenance and monitoring is not necessary to ensure continued compliance with all relevant performance standards and other technical criteria.
- An owner/operator must conduct post-closure care in accordance with the post-closure care plan, which must be completed and approved prior to the receipt or management of regulated materials, for the unit(s) in question. The post-closure care plan must include a description of the activities necessary to ensure continued compliance with all applicable performance standards and technical criteria, including structural stability, access control, activities necessary to maintain a final cover, control erosion, or to control fugitive dust. The post-closure care plan also must be certified by a qualified professional (as defined by the rule) and must be established as part of an enforceable permit.
- Post-closure care must be initiated immediately following the certification of closure and must continue for 30 years, unless the regulatory authority modifies the length of the post-closure care period.

Financial Responsibility

- Financial responsibility must be maintained by all owners/operators of existing and new units for 1) closure and, if applicable, post-closure care; 2) corrective action for known releases of parameters of concern in violation of performance standards or for design and operating criteria violations; and 3) third-party bodily injury and property damage caused by releases of parameters of concern.
- Financial responsibility for closure and post-closure care must be based on comprehensive cost estimates, in current dollars, for all planned activities assuming that the work will be performed

by a third party. Costs must be adjusted annually for inflation until closure and post-closure care is certified complete. These cost estimates must be included as a condition of an enforceable permit.

- Financial responsibility for corrective action must be based on a detailed cost estimate for performing all necessary activities according to the approved corrective action plan. The owner/operator must base the initial cost estimate on current dollars and the assumption that the work will be performed by a third party. The approved corrective action cost estimate must be included as a condition of an enforceable permit.
- Financial responsibility for third-party bodily injury and property damage caused by a release must be maintained by the owner/operator in an amount of at least $2 million per occurrence with an annual aggregate of at least $4 million, exclusive of legal defense costs. The owner/operator must demonstrate this financial responsibility coverage as part of an enforceable permit prior to the operation of the unit. The regulatory authority may, at its discretion, release the owner/operator from third-party liability financial responsibility for a given unit upon receiving certification that, at a minimum, closure of the unit has been completed.
- Financial responsibility in all cases must be maintained continuously until the regulatory authority formally releases the owner/operator following the completion of corrective action, closure, or post-closure care, as appropriate. Allowable financial responsibility mechanisms must ensure timely, adequate, and legally binding coverage and may not be cancelled without approval of the regulatory authority. Allowable mechanisms may include insurance pools, state funds, "or other such mechanisms" to demonstrate compliance with the financial responsibility requirements of the rule.

Appendix E-3

Description of Cost Model and Assumptions

Appendix E-3
Description of Cost Model and Assumptions

This appendix provides supplementary information on the methods, data, and assumptions that were employed to estimate the costs and impacts of prospective regulatory alternatives for controlling releases from special mineral processing wastes. The appendix is divided into two sections. The first outlines the legal and operational requirements of each alternative, and the second describes the development and application of EPA's cost estimating model.

1. Engineering/Operational Implications of Regulatory Scenarios

This section details the way in which prospective regulatory requirements translate into the "on the ground" waste management strategies that would be employed by affected facility operators. EPA's approach in performing this analysis was to delineate all of the applicable requirements comprising each regulatory scenario, then develop plausible waste management sequences, or "trains" for each of the potentially affected special mineral processing wastes. Plausible management practices or trains are influenced by the physical and chemical characteristics of the wastes in question, and by waste generation rates (all of which are, by definition, large), as well as by specific statutory and regulatory requirements.

Management costs associated with each pertinent regulatory scenario are estimated for each facility by identifying the specific items (and their costs) that are currently employed (in the baseline case) and that would be required under the regulatory alternatives. EPA utilized data contained in facility responses to the 1989 SWMPF survey to characterize current practices. The Agency then calculated the costs associated with each practice employed (e.g., design, construction, and operation of an unlined surface impoundment, waste stabilization, installation and operation of ground water, surface water, and/or air monitoring equipment); the sum of these costs is the total management cost at a given facility.

This technology- and facility-specific approach has resulted in management cost estimates that vary widely among facilities, even among those in the same commodity sectors. For example, EPA's cost estimate for baseline practices accounts for the presence of waste management controls such as run-on and run-off control systems and ground water monitoring. Facilities that currently employ these controls have higher current (baseline) waste management costs (all else being equal) than facilities that do not. Consequently, prospective Subtitle C or other regulation, and its attendant technical requirements (e.g., run-on and run-off controls, ground water monitoring) have reduced compliance cost implications at such facilities. Because EPA's cost analysis relies upon individual cost elements rather than unified cost functions, this variability in current waste management cost and, therefore, the incremental waste management cost associated with regulatory alternatives, can be accounted for in full.

Baseline Scenario

The baseline, or "No Action", regulatory scenario assumes that existing waste management practices will remain unchanged. The waste management practices discussed in the sector-specific chapters of this report comprise the waste management technologies employed under this scenario. In virtually all cases, assumed current waste management practices are based upon information submitted to EPA in the form of responses to the 1989 National Survey of Solid Wastes from Mineral Processing Facilities. In the few instances in which management practice information was missing or incomplete, the Agency assigned one or more management technologies based upon knowledge of the common practices used by other similar (e.g., same commodity sector and size of operation) facilities.

The most common current waste management technologies for solid and some sludge materials include placement in on-site, unlined landfills; waste piles without a cover or a base; gypsum stacks; and recycling. Wastewaters tend to be managed in on-site, unlined surface impoundments (some in combination with a gypsum stack); and in a few cases, synthetic- or clay-lined surface impoundments. Some portion of these wastewater streams is recycled at nearly all facilities.

A few facilities already meet the technical requirements of RCRA Subtitle C and are in fact, fully permitted Subtitle C Treatment, Storage, and Disposal Facilities (TSDFs). Such facilities are already subject to many of the requirements that are evaluated in this report (e.g., Subtitle C financial assurance, corrective action for continuing releases requirements), and hence, would not experience incremental compliance costs associated with these specific regulatory requirements if the special waste(s) that they generate were to be removed from the Mining Waste Exclusion. EPA has, accordingly, reflected this fact in conducting its cost and economic impact analysis.

The baseline scenario for the industry sectors covered by this report would occur under a regulatory determination by EPA that none of the solid wastes that are currently excluded from regulation under Subtitle C of RCRA by the Bevill Amendment require regulation as hazardous wastes. Even with such a regulatory determination, however, some changes in waste management practices may be required. The mineral processing industry, which has historically been exempt from federal hazardous waste management regulations under RCRA, has recently had this protection removed by a series of EPA rulemakings that were concluded on January 23, 1990 (55 FR 2322). As of the effective date of this notice (July 23, 1990 in non-authorized states), all mineral processing wastes except the 20 specific wastes considered in this report are subject to regulation as hazardous wastes (i.e., under RCRA Subtitle C) if they exhibit one or more characteristics of hazardous waste. EPA believes that many of the facilities considered in this report generate wastes that are newly subject to these requirements. Consequently, existing "baseline" management practices that are currently applied to special wastes at some of these facilities may change even if these materials are not removed from the Mining Waste Exclusion.

In addition, several states have imposed or are in the process of imposing new regulatory requirements on the operators of mineral processing facilities. For example, the State of Florida has issued a policy directive requiring that all new phosphogypsum stacks or lateral expansions of existing stacks have a clay liner; the State Department of Environmental Regulation has also indicated that it plans to initiate a formal rulemaking process for the development of phosphogypsum management regulations.

Full Subtitle C Scenario

The full Subtitle C ("Subtitle C") scenario examined here for the special study wastes is based on the premise that any of the 20 wastes exhibiting risk in the risk assessment process described above, including any that exhibit one or more RCRA hazardous characteristics (EP-toxicity, corrosivity, ignitability, or reactivity) may be regulated under Subtitle C and would then be subject to the technical requirements of 40 CFR Part 264.

EPA has examined the full array of Subtitle C regulatory requirements, and has identified those that would be most relevant from the standpoint of managing mineral processing wastes. These regulatory provisions are summarized in Appendix E-1 to this document.[1] The Agency then identified and categorized all requirements having potential cost implications.

Permitting and Administrative Requirements

In this cost impact analysis, EPA has explicitly considered and developed the cost implications of bringing a facility into the Subtitle C hazardous waste management system for the first time. Because of the high volume nature of the wastes considered in this report, the Agency believes that on-site treatment and/or disposal of these materials will continue to be the predominant means of management employed by facility operators, irrespective of the regulatory environment that may be imposed. This suggests that if any of the 20 wastes are placed into the Subtitle C system, the facilities that generate them will endeavor to become fully permitted Subtitle C Treament, Storage, and Disposal Facilities (TSDFs). Accordingly, EPA has, for this cost analysis, included the costs of developing the relevant permit applications (Part A and B) as well as necessary supporting studies, in estimating incremental Subtitle C compliance costs. Facilities that are already in the system (either as permitted TSDFs or as generators of one or more low volume hazardous wastes removed from the Mining Waste Exclusion in recent rulemakings) are assumed to experience a lesser (25 percent) expense associated with obtaining a Subtitle C permit modification for a new waste management unit.

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[1] Appendix E-1 is not designed to be an exhaustive list of all potentially applicable provisions of EPA's Subtitle C regulations.

Design and Operating Criteria

For this analysis, EPA has developed cost functions that describe the relationship between waste generation rate (hence, size/capacity of waste management units) and the cost of each component of a given waste management technology. That is, each element and its associated cost is evaluated individually at each site; these costs are then summed to yield the total cost of compliance with the relevant design and operating criteria. In this way, variable economies of scale (e.g., liner costs and ground-water monitoring costs may have different economies of scale) can be reflected in EPA's cost estimates.

Application of Assumed Waste Management Technologies

Under the Subtitle C scenario, the Agency assumes that facility operators will upgrade current waste management technologies, rather than adopt a different waste management practice or technology, unless an alternative practice would be prohibited or less costly. For example, if a waste is currently disposed in a clay-lined landfill, the waste is assumed to be disposed in a landfill with a double-synthetic liner over a clay liner to comply with Subtitle C requirements. Technologies not allowed under Subtitle C are replaced with similar technologies that comply with RCRA minimum technology requirements (e.g., disposal waste piles are replaced by RCRA landfills). Wastes currently sent to off-site disposal are assumed to continue to be managed off-site, at facilities in compliance with RCRA Subtitle C requirements unless construction and operation of new units would be less costly. Materials that are identified at some plants as being hazardous wastes may not, at other plants, be solid wastes due to alternative management practices (e.g., recycling). Internally recycled "hazardous wastes" (actually secondary materials) are assumed, under the full Subtitle C scenario, to continue to be recycled without process changes.

Some wastes currently managed using unique methods required special examination to determine the expected Subtitle C alternative management practice. For example, phosphogypsum and fluorogypsum are presently slurried with process wastewater (another special mineral processing waste) at their respective facilities, then piped to gypsum stack complexes (at most, but not all plants). Gypsum stack complexes consist of a pile containing the gypsum with an adjoining surface impoundment; these complexes serve the dual purpose of waste disposal and heat transfer (process water cooling). Gypsum slurry is pumped to one of several smaller impoundments located on top of the gypsum pile (stack), where the solids settle and eventually dewater. The process water percolates through the stack and is collected in a drainage ditch surrounding the stack complex. In some cases, the water in the ponds atop the stack is transported to the adjacent cooling pond directly.

Under Subtitle C, this practice would have to change radically. Waste gypsum would have to be disposed in a Subtitle C disposal surface impoundment. This would imply dramatic changes in the ways in which affected facilities maintain their present water balance, and in other operational factors. Although EPA is not in a position to develop sophisticated engineering analyses of such process changes that might be induced by Subtitle C regulation, the Agency has attempted to predict the actual operational consequences of imposing hazardous waste management requirements on these non-traditional waste management technologies.

Where current practice involves co-management of both potentially hazardous and non-hazardous wastes, EPA assumes that non-hazardous waste management will continue to occur in the existing waste management unit while the hazardous waste(s) will be managed in accordance with Subtitle C. The same assumption holds for situations where a potentially hazardous waste is co-managed with a mining waste. For example, copper calcium sulfate sludge which is currently disposed with mill (beneficiation) tailings would be segregated and sent to an appropriate Subtitle C management unit, but the mill tailings would continue to be disposed in the existing tailings pond. Co-management of special mineral processing wastes, non-special mineral processing wastes, and/or mineral extraction and beneficiation wastes occurs under current practice in many of the industry sectors evaluated in this report.

In general, the assumption that alternative management will involve an upgrade of existing facilities is the most reasonable prediction of future alternative waste management, given the limited data available. EPA is aware, however, that firms will make operational adjustments in response to changes in the regulatory environment in which they operate. In response to minimum technology requirements, facility operators will seek the lowest-cost waste management practice that complies with the law. In some cases, this will undoubtedly involve using new and innovative technologies or adapting existing practices to manage wastes rather than upgrading existing land disposal facilities to comply with Subtitle C. For example, many plants that currently dispose of wastes will, under RCRA Subtitle C, be provided with financial incentives to reuse or reclaim those wastes.

Unfortunately, EPA is unable to accurately identify the specific plants at which special waste management would shift towards recycling or utilization of waste materials or non-traditional waste management techniques, without highly detailed information concerning facility-specific business management and development plans. The Agency has, however, indicated which wastes may be good candidates for waste utilization, reduction, and/or recycling, and provides a limited identification and evaluation of the options available to affected facilities.

Also, facilities currently treating and storing wastes in impoundments may shift to using tank storage and treatment. They may do so to avoid complying with the minimum technology requirements for hazardous waste land disposal units, or to take advantage of the RCRA Subtitle C exemption for wastewater treatment tanks. In general, EPA believes that facilities will employ tank treatment systems rather than or in conjunction with constructing minimum technology treatment surface impoundments, and has conducted its compliance cost analysis accordingly. The Agency has performed comparative cost analyses which indicate that tank treatment in concrete impoundments is the least-cost management alternative for the waste types and within the waste generation rate ranges that are relevant to this study.

Land Disposal Restrictions

In its evaluation of the likely response of facility operators to prospective Subtitle C regulation, EPA has considered the likely impact of the Land Disposal Restrictions (LDRs). These regulations were implemented in three parts, the last of which was promulgated on May 9, 1990. LDRs establish treatment standards (BDAT) for characteristic hazardous wastes, such that any wastes exhibiting a hazardous characteristic must be treated to a defined level/with a specified technology prior to disposal on the land (e.g., in landfills or surface impoundments). In the final rule establishing BDAT for characteristically hazardous wastes, EPA explicitly declined to establish BDAT for "newly identified" wastes, including those removed from the Mining Waste Exclusion in recent rulemakings (54 FR 36592, 55 FR 2322). By implication, any wastes considered in this report that are removed from the Exclusion would also be newly identified, hence, not subject to the "Third Third" Land Disposal Restrictions. Consequently, EPA has not factored the costs of complying with the BDAT provisions contained in this rule into the present analysis, e.g., EP-toxic slags are not assumed to be ground up and cement-stabilized prior to disposal.

Nonetheless, the Agency has attempted to reflect the intent of the Land Disposal Restrictions program in defining acceptable Subtitle C management practices for the wastes considered in this report. In some cases, EPA has employed best professional judgment to specify additional steps in the treatment trains that have been applied to individual wastes; these additional steps often parallel or are identical to the BDAT specified in the recent final rule. EPA believes that in this way, compliance cost estimates that more closely parallel real-world permit conditions have resulted. For example, several of the wastewater streams considered in this report are well known to exhibit pH values less than two. Consequently, they are currently (absent the Mining Waste Exclusion) prohibited from disposal on the land (e.g., in surface impoundments) unless they have been subjected to treatment using BDAT. EPA has assumed in its cost analysis that these wastes will undergo pH adjustment in tanks prior to extended storage in impoundments. Similarly, EP toxic wastewater treatment sludges are assumed to be cement-stabilized prior to Subtitle C landfill disposal.

Corrective Action

Based upon the results of the risk assessment and damage case collection activities described in the foregoing chapters, EPA believes that some of the wastes that have accumulated at mineral processing sites may release contaminants to the environment, and therefore, require corrective action. Accurately estimating the nature and extent of and the appropriate response to existing releases at the mineral processing facilities considered in this study would, however, be an extremely difficult and complex undertaking. Consequently, the Agency has not included an explicit analysis of potential corrective action costs in this report. EPA recognizes that the prospective regulatory compliance costs provided in this document may, therefore, be underestimates.

It is important to understand, however, that only facilities that are not already subject to corrective action and generate a waste that exhibits one or more characteristics of hazardous waste that is removed from the Exclusion would experience corrective action costs that are relevant to this report. The Agency has determined which of the facilities considered in this document might enter the Subtitle C system for the first time as a consequence of the upcoming Regulatory Determination, and hence, be newly subject to corrective action requirements. These facilities are limited to those that (1) are not already Subtitle C TSDFs, and (2) do not generate a low volume, hazardous waste that was removed from the Mining Waste Exclusion by either the 9/1/89 or 1/23/90 final rules. EPA has determined that the number of such facilities is small, and that most are within one commodity sector (phosphoric acid). Therefore, the Agency does not believe that omitting a quantitative analysis of corrective action costs materially affects the findings and recommendations presented in this report.

Closure and Post-Closure Care

Subtitle C regulations require facility operators to conduct prescribed closure and post-closure care activities. Closure for land disposal units involves capping with clay and a synthetic membrane liner, installation of a leachate collection and removal system, and a revegetated soil or rock cap. For this analysis, EPA has calculated the cost of closing waste management units at the expected conclusion of their operating life, and of the maintenance, monitoring, and contaminant release control systems required under current Subtitle C regulations. Because these activities (and their costs) will not occur until well into the future, closure and post-closure care costs have been discounted to present value, then added to the other cost components (capital, operation and maintenance costs) to arrive at a total waste management cost for a given unit. Additional detail on EPA's cost estimating methods is presented below.

Financial Responsibility

Facility operators in the Subtitle C system are required to provide evidence of their ability to bear the costs associated with closure and post-closure care requirements, and with potential third-party liability. Moreover, in actual practice, facility operators may be required to provide assurance of their ability to respond to both sudden and non-sudden contaminant releases from their units (corrective action), though EPA's final rule addressing financial assurance for corrective action has not yet been promulgated. For this analysis, EPA has factored in a cost to account for financial responsibility concerns for all facilities potentially subject to Subtitle C regulation. This cost varies among facilities, depending upon whether the firm owning the facility (or corporate parent) is able to pass the "Financial Test." Firms with adequate financial resources to pass this test experience a much lower effective cost for providing financial assurance than other firms.

Subtitle C-Minus Scenario

To assess the potential costs and impacts of less stringent regulation, EPA has evaluated an intermediate Subtitle C scenario ("Subtitle C-Minus") that assumes that EPA exercises all of the regulatory flexibility provided by Section 3004(x) of RCRA. Section 3004(x) does not give EPA authority to waive Subtitle C authority based on cost alone. Rather, this provision allows EPA to provide some regulatory flexibility to mitigate the economic impacts of Subtitle C regulation on the minerals industry provided that adequate protection of human health and the environment is ensured. This flexibility allows EPA to modify the relevant provisions to take into account the special characteristics of mining and mineral processing wastes, practical difficulties in implementing the specific RCRA Subtitle C requirements, and site-specific characteristics.

As discussed in Chapter 2, this scenario uses the same assumptions as the full Subtitle C regulatory scenario, with three notable exceptions:

- The prohibition on placing liquids in Subtitle C landfills does not apply;
- Land Disposal Restrictions do not apply; and
- On-site waste management practices, for special mineral processing wastes meet only pre-HSWA Subtitle C technological requirements, rather than the minimum technology required under 3004(o) and 3005(j) of the amended RCRA.

Under the Subtitle C-minus scenario, therefore, EPA assumes that facilities continue to replace or expand disposal units without (generally) installing double liners and leachate collection systems, to dispose materials in landfills in slurry form, and to continue to manage wastes without applying BDAT prior to land disposal.

For purposes of estimating the costs of this regulatory alternative in this Report to Congress, EPA has identified what it tentatively believes would be the absolute minimum allowable extent of regulation under Subtitle C (i.e., the maximum allowable application of regulatory flexibility). As discussed in Chapters 1 and 2, however, EPA is in no way suggesting or implying that the model used for costing purposes in preparing this report represents what the Agency could legally or would determine is an appropriate application of RCRA §3004(x). EPA has solicited comments on whether this model reasonably reflects allowable practices under §3004(x). The Agency has applied regulatory flexibility under this scenario on a site-specific basis, taking into consideration not only existing waste management practices, but also the environmental settings (risk potential) of the individual facilities. Consequently, the requirements that apply to a facility in an environmentally sensitive area are more stringent under this scenario than they are for a facility located in an area with lower risk potential.

To establish the design and operating criteria that would apply to facilities under the Subtitle C-Minus scenario, EPA evaluated each potentially affected plant in terms of the vulnerability of the environmental media found at the site, focusing on ground water resources. Each facility was placed into a category (low, moderate, or high risk potential) based upon an evaluation of intrinsic site characteristics (e.g., depth to ground water, net recharge, soil composition), damage case findings, and risk analyses (quantitative modeling results) that was conducted for this report. The site-specific results of this effort are presented in Exhibit E-3-1. These categories determined the specific design and operating standards that were required for the facilities and, in fact, whether certain currently used management technologies (disposal waste piles) were even allowed under the Subtitle C-Minus scenario. These design and operating criteria are presented by risk potential category and management technology in Exhibit E-3-2.

Exhibit E-3-1
Ground-Water Contamination Potential of Sites Modeled in the Cost/Economic Impact Analysis

Sector/Site	Ground-Water Contamination Potential	Rationale
PB/ASARCO/E. Helena, MT	Moderate	Observed contamination potentially attributable to slag pile, although there is also upgradient contamination and contamination downgradient may be due to former practice of sprinkling the pile for dust suppression; modeling also predicts slight contamination
PB/ASARCO/Glover, MO	High	Observed contamination that is likely attributable to slag pile; modeling also predicts contamination; karst terrane may facilitate contaminant migration
PB/ASARCO/Omaha, NE	Low	No observed contamination; modeling predicts no contamination in 200 years; very shallow ground water (2 m), but low net recharge (5 cm/yr) and impermeable unsaturated zone (primarily silt and clay)
PB/Doe Run/Boss, MO	Moderate	Observed contamination, although may be due to on-site impoundments; modeling predicts no contamination; low recharge (5 cm/yr) and large depth to ground water (45 m), but potential for karst terrane may facilitate contaminant migration
PB/Doe Run/Herc., MO	Low	No observed contamination; modeling predicts no contamination; ground water moderately shallow (8 m), but very low recharge (2 cm/yr) and impermeable unsaturated zone (silt and clay)
CU/ASARCO/Hayden, AZ	Low	Modeling predicts no contamination; ground water moderately shallow (6 m), but very low net recharge (1 to 2.5 cm/yr)
CU/Phelps/Playas, NM	Low	Although ground water shallow (4 m), essentially zero recharge
CU/Kennecott/Garfield, UT	Low	Ground water moderately shallow (8 m), but recharge very low (<1 cm/yr) and impermeable unsaturated zone (primarily silt and clay); modeling predicts no contamination in 200 years
MG/Magcorp/Rowley, UT	Low	Impoundment designed to have wastewater infiltrate into ground as a way to reduce volume; ground water shallow (5 m); subsurface permeable (primarily sand); State tracking seepage and indicates that it poses a low risk; low potential for exposure because shallow ground water is saline (connected with Great Salt Lake)
ZN/ZCA/Monaca, PA	Low	Although high recharge (25 cm/yr), ground water is deep (24 m); on-site monitoring has not identified any contamination; modeling predicts no contamination in 200 years
HA/Allied/Geismar, LA	Moderate	Standing quantity of process wastewater provides a hydraulic head to drive contaminants to shallow (3 m) ground water, and contamination seeps observed around the clearwell pond; however, shallow aquifer appears to discharge into river without use, and uppermost useable aquifer is deep (55 m)
FE/LTV/E. Cleveland, OH	Moderate/Low	Ground water deep (23 m); recharge moderate (15 cm/yr); unsaturated zone moderately permeable (loamy sand)

Exhibit E-3-1 (cont'd)
Ground-Water Contamination Potential of Sites Modeled in the Cost/Economic Impact Analysis

Sector/Site	Ground-Water Contamination Potential	Rationale
FE/Bethlehem/Sparrows Pt, MD	Moderate	Ground water very shallow (2.5 m), recharge high (28 cm/yr), and unsaturated zone moderately permeable (loamy sand); however, low potential for exposure because shallow ground water brackish (not drinkable) and public water provided from distant supply
FE/Sharon/Farrell, PA	Moderate	Ground water shallow (5 m); recharge moderate (15 cm/yr); permeable unsaturated zone (gravelly sandy loam)
FE/USS/Fairless Hills, PA	High	Ground water shallow (4 m); recharge high (23 cm/yr); permeable unsaturated zone (sand and gravel)
FE/USS/Lorain, OH	Moderate	Ground water moderately deep (15 m); recharge low (8 cm/yr); very impermeable unsaturated zone (shale); APC dust/sludge managed in impoundment, which has standing liquids that provide a hydraulic head to drive contaminants into the subsurface
TI/DuPont/New John., TN	High	Waste solids managed in impoundments, which have standing liquids that provide a hydraulic head to drive contaminants into the subsurface; ground water moderately deep (11 m); unsaturated zone impermeable (primarily silt and clay)
TI/SCM #1 and #2/Ashtabula, OH	High	Waste solids managed in impoundments, which have standing liquids that provide a hydraulic head to drive contaminants into the subsurface; ground water moderately shallow (6 m); impermeable subsurface (primarily silt and clay)
TI/Kerr-McGee/Hamilton, MS	High	Waste solids managed in impoundments, which have standing liquids that provide a hydraulic head to drive contaminants into the subsurface; ground water moderately shallow (6 m); permeable subsurface (primarily sand); modeling predicts contamination
TI/Timet/Henderson, NV	High	Waste solids managed in impoundments, which have standing liquids that provide a hydraulic head to drive contaminants into the subsurface; ground water moderately deep (12 m); permeable subsurface (primarily sand)
PA/Central/Plant City, FL	High	Observed contamination in surficial and upper Floridan aquifers attributed to gypsum stack and ponds
PA/CF Chemicals/Bartow, FL	High	Observed contamination in surficial aquifer attributed to gypsum stack and ponds; State has initiated enforcement action in response
PA/Mobil/Pasadena, TX	High	No observed contamination or damage case; ground water very shallow (2.5 m); impermeable subsurface (primarily clay); standing quantity of process wastewater provides a hydraulic head to drive contaminants into subsurface
PA/Arcadian/Geismar, LA	Moderate	Contamination in shallow (3 m) ground water attributed to gypsum stack and clearwell areas, but contamination likely to discharge directly into nearby river and usable aquifer deeper (55 m) and more protected

Exhibit E-3-1 (cont'd)
Ground-Water Contamination Potential of Sites Modeled in the Cost/Economic Impact Analysis

Sector/Site	Ground-Water Contamination Potential	Rationale
PA/Royster/Mulberry, FL	High	Observed contamination in surficial aquifer attributed to gypsum stack and ponds; State has initiated enforcement action in response
PA/Agrico/Donaldsonville, LA	High	Observed contamination of shallow aquifer attributed to gypsum stack and ponds
PA/Conserv/Nichols, FL	High	Observed contamination in surficial aquifer attributed to gypsum stack and ponds; State has initiated enforcement action in response
PA/Agrico/Mulberry, FL	High	Observed contamination in surficial aquifer attributed to gypsum stack and ponds; State has initiated enforcement action in response
PA/U.S. Agrichem/Ft. Meade, FL	High	Observed contamination in surficial aquifer attributed to gypsum stack and ponds; State has initiated enforcement action in response
PA/Nu-West/Soda Springs, ID	High	Observed ground-water contamination due to dike failure and large spill; inconclusive data suggest that some leakage may be occurring presently
PA/Seminole/Bartow, FL	High	Observed contamination of surficial and deeper usable aquifers that is potentially attributable to gypsum stacks and associated ponds
PA/Gardinier/Riverview, FL	High	Observed contamination of surficial aquifer that is potentially attributable to the gypsum stack and process wastewater ponds
PA/Nu-South/Pascagoula, MS	High	Although no documented contamination or damage case, process wastewater provides a hydraulic head that may drive contaminants to the subsurface; ground water very shallow (1.5 m); subsurface permeable (primarily sand)
PA/Texasgulf/Aurora, NC	High	Observed contamination in surficial and usable intermediate aquifer attributed to process wastewater ponds; although dike failure at gypsum stack has resulted in large spills of wastewater, the gypsum stack is not clearly implicated as a source of continuing ground-water contamination
PA/Chevron/Rock Springs, WY	Low	No documented contamination or damage case; ground water very deep (122 m); subsurface a fractured shale that is generally impermeable, although contaminants could readily migrate in fractures; process wastewater provides a hydraulic head that could drive contaminants to the subsurface, but natural recharge very low (<1 cm/yr) and leaching from dried gypsum very unlikely
PA/IMC Fert./Mulberry, FL	High	Observed contamination of surficial and usable Floridan aquifers attributed in part to the gypsum stack and associated ponds
PA/Royster/Palmetto, FL	High	Observed contamination in surficial aquifer potentially attributed to gypsum stack and associated ponds; State has initiated enforcement actions in response

Exhibit E-3-1 (cont'd)
Ground-Water Contamination Potential of Sites Modeled in the Cost/Economic Impact Analysis

Sector/Site	Ground-Water Contamination Potential	Rationale
PA/Agrico/Uncle Sam, LA	High	Documented site contamination that may be partly due to phosphogypsum and process wastewater management units; ground water shallow (3 m); subsurface relatively impermeable (primarily clay and silt); process wastewater provides a hydraulic head to drive contaminants into subsurface; natural recharge that seeps through dried gypsum very low (2.5 cm/yr)
PA/Farmland/Bartow, FL	High	Observed contamination in surficial aquifer that may be attributed to phosphogypsum and process wastewater management units; State has initiated enforcement action in response
PA/J.R. Simplot/Pocatello, ID	High	Process waste water provides a hydraulic head that may drive contaminants to the subsurface; ground water moderately shallow (9 m); subsurface very permeable (primarily sand and gravel); natural recharge available to seep through dried gypsum very low (1 cm/yr)
PA/Occidental/White Springs, FL	High	Process waste water provides a hydraulic head that may drive contaminants to the subsurface; ground water moderately deep (14 m); karst terrane may allow contaminant transport in solution cavities; high natural recharge (30 cm/yr) available to seep through any dried gypsum

At present, some generators of special mineral processing wastes ship their waste(s) off-site for disposal. Under the Subtitle C-Minus scenario, as for the other scenarios considered in this analysis, EPA has assumed that this practice will continue if on-site management is more expensive than off-site disposal. Candidate Subtitle C wastes managed off-site, however, are assumed to be sent to facilities that comply with all provisions of Subtitle C, i.e., the facilities that receive such wastes do not receive the flexible management standards that apply to on-site management under Subtitle C-Minus. All other assumptions made for the full Subtitle C regulatory scenario with respect to the choice of waste management technologies apply to the Subtitle C-Minus regulatory scenario as well.

Subtitle D-Plus Program Scenario

The third and final regulatory alternative considered by the Agency for this analysis of regulatory costs and impacts is regulation under one possible approach to a RCRA Subtitle D program tailored to address the special characteristics of large volume mineral processing wastes. The Agency could consider applying such a Subtitle D program to any of the 20 mineral processing wastes subject to this study that are permanently excluded from regulation under RCRA Subtitle C.

Substantively, this approach would be a state-implemented program based on a minimum set of federal technical criteria and provisions for state program primacy. The technical criteria contained within the hypothetical Subtitle D-Plus program consist essentially of provisions for the state establishment of media-specific performance standards for ground water, surface water, air, and soils/surficial materials. It would also establish technical criteria for a variety of required owner/operator activities, including design and operating

Exhibit E-3-2
Design and Operating Criteria, and Other Requirements Under the Subtitle C- Scenario

Waste Management Practice	Ground Water Exposure/Risk Potential		
	Low	Moderate	High
Waste Pile Disposal	Current Liner Configuration Ground-Water Monitoring Soil/Rock Cap, Regrade as Necessary	Not Allowed	Not Allowed
Surface Impoundment Disposal	Current Liner Configuration Ground-Water Monitoring Soil/Rock Cap	Composite Liner (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection	Composite Liner (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection
Surface Impoundment Storage/Treatment	Current Liner Configuration Ground-Water Monitoring	Composite Liner (new unit) Ground-Water Monitoring Clean Closure	Composite Liner (new unit) Ground-Water Monitoring Clean Closure
Landfill Disposal	Current Liner Configuration Ground-Water Monitoring Soil/Rock Cap	3-ft. Thick Clay Liner (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection	Composite Liner/Leachate Collection (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection
Gypsum Stack Disposal	Current Liner Configuration Ground-Water Monitoring	Composite Liner/Leachate Collection (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection	Double Composite Liner/ Leachate Dectection (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection

criteria, monitoring criteria, corrective action requirements, closure and post-closure care criteria, and financial responsibility requirements.

In addition, the program would require the periodic characterization of regulated materials and a number of general and location-specific analytic studies designed to ensure that regulated materials management and closure activities are adequately protective of human health and the environment. Specific operating and closure requirements (e.g., the use of liners, placement of caps), however, are left in large part to the discretion of the states. Because this would be a Subtitle D program that is similar in many respects to current state Subtitle D solid and industrial waste regulatory provisions, and because the program would give considerable flexibility to the states regarding the application of specific waste management and closure requirements, EPA anticipates that the incremental requirements of the program above baseline conditions would in many cases be minimal.

Design and Operating Criteria

For this analytical scenario, EPA established a variety of design and operating criteria, including structural stability requirements, requirements applicable to land application activities and for the protection of biological resources, and location-specific criteria for units located in floodplains, seismic impact zones and unstable/fault areas, Karst Terrane, and wellhead protection areas (as defined by states pursuant to Safe Drinking Water Act requirements). The state also would have the flexibility to establish unit-specific requirements by rule or guidance. Owner/operators would have to follow management practices specified by the state for any unit for which media-specific performance standards are established by the state (based on the regulated materials characterization) in order to ensure compliance with those performance standards.

EPA believes that, aside from analytic studies required as part of the location-specific criteria and periodic inspections by third parties for structural stability, many of the requirements that would apply under the Subtitle D-Plus scenario are in fact currently required under existing state regulatory programs. In order to estimate the incremental costs of this regulatory alternative's design and operating criteria, therefore, the Agency used empirical data and best professional judgment to calculate the costs of such analytic studies.

The Agency has applied the Subtitle D-Plus scenario design and operating criteria in much the same way as it has the analogous requirements of the Subtitle C-Minus scenario, i.e., on a risk-based, site-specific basis. EPA has used the risk potential categories described above (see Exhibit E-3-1) to establish the standards that apply to waste management units under the Subtitle D-Plus scenario for each potentially affected facility. The specific requirements that apply for each category and waste management technology are presented in Exhibit E-3-3. It is important to note that with the exception of sites in the "low" risk potential category, facilities would be required to manage the special wastes in lined waste management units; in most instances, this implies construction of new units, rather than continued use of existing units. Consequently, for many facilities, the difference between the Subtitle C-Minus and Subtitle D-Plus scenarios is minimal, in terms of the activities (and associated costs) that would be mandated under these two regulatory alternatives.

Monitoring

Under the Subtitle D-Plus scenario, owner/operators would have to establish ground-water, surface water, and/or air monitoring systems for any units for which ground-water, surface water, and/or air performance standards, respectively, are established by the state. Unlike Subtitle C, however, this approach would provide for demonstrations by the owner/operator that management practices adequately isolate and contain the waste(s) so that a release of hazardous constituents would not occur. The program would, in fact, encourage the adoption of such management practices in lieu of the establishment of monitoring systems. EPA believes that, if this management practices approach were not adopted, then the monitoring requirements established by the state would essentially equate to monitoring requirements provided for under current regulation. In order to estimate the incremental monitoring costs of the Subtitle D-Plus approach above baseline, therefore, EPA calculated for each waste stream the cost of management practices that could be used to isolate and contain the waste and/or the cost of demonstrating that such management practices would warrant the waiver of monitoring requirements. The Agency believes, however, that only facilities having a "low" risk potential would be able to demonstrate isolation/containment and therefore be eligible for a waiver of the requirements; facilities in the "moderate" and "high" risk potential categories would be required to conduct monitoring (including ground water monitoring) in all cases

Corrective Action

The corrective action provisions established under the Subtitle D-Plus scenario are essentially the same requirements made under current Subtitle C regulation. The principal difference between the two programs is that Subtitle D-Plus corrective action requirements would apply only to releases from regulated units and not to all other waste management units within the facility boundary. Therefore, in the event that the Subtitle D-Plus program described here were to be promulgated, corrective action costs would be the same, or quite possibly lower, than Subtitle C corrective action costs. In addition and as discussed above, the Agency does not believe that acccurately estimating corrective action costs for this study is tractable, nor would it be likely to significantly change the findings or implications of this report. As a result, EPA has not estimated corrective action costs for the Subtitle D-Plus scenario.

Exhibit E-3-3
Design and Operating Criteria, and Other Requirements Under the Subtitle D-Plus Scenario

Waste Management Practice	Ground Water Exposure/Risk Potential		
	Low	Moderate	High
Waste Pile Disposal	Current Liner Configuration	Concrete Liner (new unit) Leachate/Run-off Treatment Ground-Water Monitoring	Concrete Liner (new unit) Leachate/Run-off Treatment Ground-Water Monitoring Composite Cap/Run-off Collection
Surface Impoundment Disposal	Current Liner Configuration	Composite Liner (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection	Composite Liner (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection
Surface Impoundment Storage/Treatment	Current Liner Configuration	Composite Liner (new unit) Ground-Water Monitoring Clean Closure	Composite Liner (new unit) Ground-Water Monitoring Clean Closure
Landfill Disposal	Current Liner Configuration	3-ft. Thick Clay Liner (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection	Composite Liner/Leachate Collection (new unit) Ground-Water Monitoring Composite Cap/Run-off Collection
Gypsum Stack Disposal	Current Liner Configuration	3-ft. Thick Clay Liner (new unit) Sand Layer/Geotextile Leachate/Run-off Treatment Ground-Water Monitoring	Composite Liner (new unit) Leachate/Run-off Collection and Treatment Ground-Water Monitoring

Closure and Post-Closure Care

The closure and post-closure care provisions of EPA's Subtitle D-Plus approach, as with the rest of the program, would allow considerable flexibility to the states in establishing the specific requirements applicable to owner/operators. EPA believes that states would, in some cases, require closure and post-closure care activities that are similar to those established under Subtitle C programs. Cases where this approach would likely apply include the closure of surface impoundments and tank treatment systems. Such activities might include the removal of wastes, decontamination of soils and equipment, and/or the installation of rock caps or soil caps with revegetation. For waste piles and landfills, states would likely require actions designed to stabilize, isolate, and contain wastes, such as chemical fixation to control wind dispersal, permanent run-on/run-off controls, and neutralization to immobilize metals. EPA believes that the removal of materials from large waste piles or landfills, or the retrofitting of liners, would not be required. Post-closure care would apply to any unit containing special wastes after closure and consist of periodic inspections and the maintenance of run-on/run-off controls, site-access controls, and other ongoing closure activities for a period of 30 years.

Data gathered from the 1989 SWMPF Survey suggest that in general, owner/operators are not currently facing state-imposed closure or post-closure care requirements. The application of the Subtitle D-Plus program to mineral processing wastes, therefore, would impose incremental costs above the baseline. EPA believes that these costs would resemble those incurred under the Subtitle C scenario, and hence has computed them in the same manner, accounting fully for differences in final cover material, monitoring requirements, etc. In addition, EPA estimated the present value cost of preparing closure and post-closure care plans based on typical costs for such plans under Subtitle C requirements.

Financial Responsibility

The financial responsibility provisions established by the prospective Subtitle D-Plus program are the same as the provisions established under Subtitle C, including coverage for source control and remediation of known releases (i.e., corrective action), coverage for closure and post-closure care, and Environmental Impairment Liability (EIL) coverage (i.e., for third-party damages).

2. Cost Model Development

Conceptual Waste Management Practices

The three alternative regulatory scenarios considered in this report are based upon Subtitle C of RCRA, a "Subtitle C-Minus" alternative based upon RCRA §3004(x), and a site-specific, risk-based Subtitle D-Plus approach. For each alternative scenario, EPA has considered the appropriate legal requirements (described in the preceding section), and the physical and chemical characteristics and generation rates of each waste stream analyzed, as well as the technical feasibility of implementing particular waste management technologies or treatment trains. The result is a well-defined, and quite limited, set of management practices that are available to facility operators generating one or more of the special mineral processing wastes. Not surprisingly, the options under the full Subtitle C scenario are more limited both in number and in the manner in which they can by employed than the options available under the other alternative regulatory scenarios. The management options that the Agency believes would be available and feasible within each of the regulatory alternatives are described in the following paragraphs.

Subtitle C

Because of the physical/chemical nature of the special mineral processing wastes and the strict technical standards of Subtitle C, EPA has identified only four primary ways of disposing of the special mineral processing wastes: solids must go to landfill disposal, sludges/slurries generally report to surface impoundment storage/stabilization/disposal system, slurried solids (e.g., phosphogypsum) go to a disposal impoundment, and wastewaters are subjected to tank/surface impoundment treatment, then discharged or recycled. Because all of the wastes of interest are inorganic, other types of technologies (e.g., incineration, solvent recovery) are unavailable. Wastes can also be recycled or recovered, in addition to being disposed or treated. Under Subtitle C, permanent disposal of material in waste piles is not permitted, though these units may be used for storage. All land-based units, whether they are used for storage, treatment, or disposal, must contain impermeable liners, have leachate collection systems, and meet other technical standards, such as closure requirements. Hence, units such as gypsum stacks are not allowed under the Subtitle C scenario.

Subtitle C-Minus

Section 3004(x) of RCRA allows the EPA Administrator to relax certain Subtitle C requirements for landfills and surface impoundments, i.e., other types of units are ineligible for modified requirements. Among the HSWA requirements that may be relaxed are the prohibition on placing liquids in landfills, requirements specific to interim status surface impoundments, corrective action requirements for continuing releases, the Land Disposal Restrictions (LDRs), and the minimum technical standards that apply to new land disposal units (e.g., landfills, surface impoundments).

In EPA's view, only the last two of these provisions have much conceptual significance to the Report to Congress, because: 1) liquids in landfills is an unimportant issue because of the nature of the wastes in question (sludges will report to surface impoundment or landfill disposal, depending upon moisture content); 2) the interim status provisions have expired (as of 1988); and 3) as discussed above, most of the facilities of interest are already subject to Subtitle C corrective action provisions.

Relaxation of the minimum technical standards, on the other hand, implies some important changes to the ways in which special wastes may be managed. For example, units may be lined with clay rather than two synthetic liners, and may be closed without installing a RCRA Subtitle C cap. As a consequence, waste management costs would be reduced, though the types of waste management practices that are technically feasible under this scenario generally parallel those that would be available under the full Subtitle C scenario.

One important exception to this is that gypsum stacks would be allowed under Subtitle C-Minus, though in significantly altered form. Subtitle C-Minus gypsum stacks that would be located in "moderate" or "high" risk potential areas would be required to have single and double synthetic liners, respectively, as well as leachate collection and ground-water monitoring systems. In addition, these units would need to be capped at unit closure with a composite (clay/synthetic) cap, run-off collection system and soil or rock cap. To accomplish this, the shape of gypsum stacks would have to change dramatically. Rather than the steep sides that characterize most existing stacks, side slopes on Subtitle C-Minus gypsum stacks could not exceed a slope of three to one (approximately 18 degrees), so as to enable the operator to emplace and maintain the cap at closure. As a result, new gypsum stacks that would be constructed under this scenario would require far more land area for disposal of a given quantity of gypsum than conventional stacks. Because most of the major capital and operating costs of land disposal are a function of area, this difference implies major impacts on waste management costs at affected facilities.

As discussed above, the Land Disposal Restrictions program would not immediately apply to any of the 20 special wastes if they were to be removed from the Mining Waste Exclusion. Nonetheless, EPA did include an extra step in the full Subtitle C costing scenario to account for a plausible means of achieving the objectives of the LDRs for sludge materials (cement stabilization). In the Subtitle C-Minus scenario, however, the assumption that EP toxic sludges would need to be cement-stabilized prior to land disposal has been relaxed, resulting in a significant decrease in the total cost of managing these wastes, as compared to full Subtitle C.

Subtitle D-Plus

The conceptual Subtitle D-Plus program for mining and mineral processing wastes is a site-specific, risk-based approach for controlling environmentally significant releases from waste management units. Under this scenario, waste streams are evaluated on a facility-specific basis, in much the same way as they are under the Subtitle C-Minus scenario:

- If the waste does contain constituents of concern for a particular pathway but the facility is located in a setting with "low" risk potential, the operator may demonstrate that his management practices (current or prospective) limit releases sufficiently to eliminate any potential risk. In such cases, the operator may comply with program requirements by "adding on" to existing waste management controls, rather than by constructing new waste management units. For example, wastes that contain chromium in sufficient concentrations to pose risk through entrainment of waste dust and downwind exposure to humans may be controlled by use of dust suppression techniques without triggering the full array of Subtitle D-Plus program requirements. Thus, under the Subtitle D-Plus scenario, wastes that exhibit characteristics of hazardous waste may continue to be managed as they are currently, though some additional control measures may be required (e.g., run-on/run-off controls, dust suppression).
- In cases where the risk potential is "moderate" or "high," the other aspects of the program are applicable. These include design and operating criteria, monitoring, closure and post-closure care requirements, and financial responsibility provisions, as described in the previous section. Because most facilities considered in this report are not in compliance with these criteria, most facilities for which risk potential is moderate or high would have to construct new units if this scenario were to be applied.

Components of the Cost Model

EPA's cost estimating model has two major components: design modeling and cost estimation. For any type of waste management practice, it is first necessary to calculate the capacity (physical volume for disposal units and throughput for treatment units) that will be required to manage the waste(s) of interest. Then the model moves to the second component, which involves assembling the various cost elements that in combination comprise a waste management practice, and estimating the cost associated with each element. Because different elements are in reality a function of different input variables, and because the elements of interest vary between facilities and among scenarios, the Agency's modeling approach yields a more realistic view of both current and alternative waste management costs than simple, aggregated cost modeling functions.

Design Model

For wastes that are assumed to be managed in land-based units (e.g., landfills, surface impoundments), the first step in evaluating waste management costs is to determine the capacity and dimensions of the waste management unit. The size of the unit is dependent on four user-supplied (in this case, site-specific) variables: waste generation rate, the percent of solids contained in the waste (for liquids and sludges), the settled density of these solids (if applicable), and unit operating life. Based on these factors, the model will calculate the dimensions of a unit large enough to accomodate the predicted accumulation of waste or treatment residue over the operating life of the unit (15 years for disposal units). In the case of surge ponds (i.e. storage surface impoundments, the necessary capacity (throughput) is calculated based upon a retention time of one day, i.e., the capacity is one-365th of the annual waste generation rate for a wastewater with low solids content. In the case of storage waste piles, the necessary capacity (throughput) is calculated based upon a retention time of one week.

Dimensions are based on the assumption that land-based units are square, and are constructed by excavating the interior and using the material removed to construct berms along each edge. Berms are built with a three-to-one slope both inside and outside, and have a flattened top that varies in width with the size of the unit; small units have a berm wide enough to walk on and visually inspect (six feet), while larger units have progressively wider berms (up to 40 feet) so as to enable vehicles to traverse the top (moderately large units) or cranes to be placed on the top of the berm and excavate material from inside the unit (large units).

For this analysis, EPA has made the assumption that all new units are constructed on-site, i.e., facilities currently have enough land to construct new units of adequate size. This implies that wastes will not have to be transported significant distances prior to disposal, and that facilities will not need to purchase additional land at current market prices (though there is an opportunity cost). The Agency has captured the opportunity cost by including a nominal land cost in calculating the cost of the unit; the number of acres required exceeds the area of the unit by approximately 20 percent, to allow for a buffer zone. This approach and its underlying assumptions are based on review of responses to the National Survey, and personal observations made during EPA visits to numerous mineral processing facilities.

The design modeling process yields a number of unit dimensions and other data that serve as inputs to the cost element equations. Some costs are a function of the total area of the unit, while others are directly related to the interior surface area of the unit, unit perimeter, and/or other variables.

Costing Model

Once the dimensions of the unit have been specified, the cost of each required element is calculated, based upon one or more of these dimensions. Individual element costs are summed to yield the total cost of the management practice. The specific elements that are required for a given practice depend upon the type of unit(s) employed and the requirements of the regulatory scenario being examined. Scenarios contain both general and unit-specific components, which are discussed in the following paragraphs.

General Components. For each regulatory scenario, EPA has made provisions for any cost that would be required of the facility operator either at the facility level or that applies equally to any type of waste management unit. Examples of these general cost components include (to a first approximation): permitting, financial asssurance, and site security.

Unit-Specific Components.

- Landfills-The conceptual landfill that the Agency has developed is a large monofill that is fully constructed in the first year, receives material continuously throughout its operating life (does not have individual cells), and is closed with a cap and cover that encloses the entire unit upon closure. EPA selected this design because it has the lowest cost (greatest capacity for a given area, lowest permitting cost, etc.), and because there is no requirement (even under Subtitle C regulations) for individual cell construction or annual cell closure.
- Surface Impoundments-Surface impoundment construction closely parallels that of landfills. Disposal surface impoundments are assumed to fill up and require closure at the end of the operating life; these units are closed in the same way as landfills (for a given scenario).
- Waste Piles-These units do not require excavation, but do require liners or bases and covers under some scenarios. Storage waste piles require at least annual turnover of inventory and must be clean closed.
- Gypsum Stacks-Gypsum stacks are represented as a waste pile topped with an unlined surface impoundment. The cost of constructing and operating the stack includes a component for the gypsum slurry pipeline. Under the Subtitle D-Plus scenario, these units are assumed to be lined with clay, while under the Subtitle C-Minus scenario, stacks are lined with one or more synthetic liners, depending upon site-specific risk potential (gypsum stacks are not allowed under the full Subtitle C scenario).
- Tank Treatment-EPA has relied upon previous analytical work in developing costs for tank treatment of hazardous wastewaters. The Agency believes that these existing equations are valid within the entire range of waste generation rates considered in this report, and hence, do not require modification for this analysis.
- Off-Site Disposal/Utilization-EPA has incorporated a simple per-ton cost for disposing wastes and treatment residues off-site in either Subtitle C or D landfills into the cost model. Unit costs for off-site disposal of wastes are based upon recent contacts with commercial landfill operators. The Agency does not have adequate data to ascribe costs or credits associated with manufacturing and selling waste-related products; consequently, no such costs/credits have been built into the model.

Application to Special Mineral Processing Wastes

In this section, EPA describes the way in which specific waste streams have been assigned to management trains/technologies for each scenario of interest, some of the region- and site-specific flexibility that the Agency has built into the costing model, and the analytical assumptions that have been used in conducting the cost modeling runs.

Assignment of Waste Streams to Management Trains/Technologies

Waste streams are first identified as candidates for regulation under a particular scenario on the basis of chemical characteristics and, for the Subtitle D-Plus scenario, on a site-specific evaluation of current waste management practices. Wastes that exhibit one or more characteristics of hazardous waste are assumed to be candidates for regulation, at the facilities at which EPA's data indicate that the waste may be hazardous.

Facilities for which waste constituent data are unavailable are generally assumed to pass the criteria that apply to each scenario, with certain sector-specific exceptions.

Subtitle C

Under the Subtitle C scenario, solid materials (copper, lead, and zinc slags, iron/steel APC dust/sludge) are managed in Subtitle C landfills. Slurried solids (phosphogypsum) are managed in Subtitle C disposal surface impoundments (disposal surface impoundments must comply with landfill closure requirements). Sludge and sludge solids (titanium tetrachloride waste solids, calcium sulfate WWT sludge) are settled in storage/treatment impoundments, cement stabilized, then disposed in Subtitle C landfills. Wastewaters containing small amounts of suspended/dissolved solids (phosphoric acid, hydrofluoric acid, and magnesium process wastewaters) are collected in small surge ponds, managed in treatment tanks for pH adjustment, and then routed to their current points of storage, reuse, or discharge. Sludges from this tank treatment are assumed to be non-hazardous and are disposed in a Subtitle D monofill.

Subtitle C landfills and surface impoundments are constructed using two liners with leachate collection systems above and between them, a geosynthetic membrane above the upper leachate collection system, ground-water monitoring systems along the downgradient edge (half the perimeter) of each unit, and run-on and run-off controls. EPA's run-on/run-off control equations account for whether a facility is located in a floodplain, in which case surface water control is more difficult and expensive. At closure, these units are capped with a composite liner and either a layer of clay covered with topsoil or a layer of sand with a leachate collection system and a rock cap, depending upon the region in which the facility of interest is located (as discussed more fully below).

Subtitle C-Minus

Under the Subtitle C-Minus scenario, wastes are generally managed using the same technologies as under Subtitle C, but the design requirements that apply to the units themselves are far less stringent. Section 3004(x) of RCRA allows for the relaxation of the HSWA minimum technical standards for landfills and surface impoundments, as discussed above. Accordingly, EPA has assumed that some of the more complex and expensive requirements would be modified under this scenario. The primary differences involve use of single clay/synthetic liners (except in the case of gypsum stacks located in high risk areas) rather than the double synthetic liner/leachate collection system and synthetic/clay/topsoil cap configurations required under full Subtitle C. Most other Subtitle C requirements (e.g., permitting, financial assurance, ground-water monitoring) apply in full in this scenario. As discussed above, modified gypsum stacks are allowed under the Subtitle C-Minus scenario. Cement stabilization of sludges is not required; sludge, therefore, is disposed in a disposal surface impoundment.

Subtitle D-Plus

The Subtitle D-Plus scenario allows for more flexibility on the part of the operator than either of the Subtitle C scenarios. Facility operators may use or adapt existing waste management technologies (e.g., disposal waste piles) in more situations than they can under the Subtitle C-Minus scenario. Under this scenario, EPA has assumed that any facility that manages a waste that contains constituents of concern would first attempt to institute a constituent control mechanism to reduce or prevent releases (e.g., run-on/run-off controls, dust suppression). This strategy could be effective if the potential pathway(s) of concern involved air or surface water, but would insufficient if there is a moderate or high potential threat via ground water at a given site. In that case, requirements for a containment system (i.e., liner), ground water monitoring, and the other aspects of the full Subtitle D-Plus program would be triggered.

The sectors and facilities that generate one or more wastes that may exhibit EP toxicity or corrosivity or have resulted in documented damages are analyzed using the model. Facilities generating wastes that do not contain constituents of concern are subject only to periodic waste testing and waste management structural stability requirements; EPA has computed the more or less fixed, constant, and modest costs associated with these requirements outside the cost model itself. Cost model input data files contain variables that indicate the pathway(s) that may be of concern for a given facility; these data are based directly on the descriptive risk analyses that the Agency developed for the risk assessment portion of this report. If these data indicate that only air and/or surface water pathways are important (i.e., low ground water risk potential), then the model calculates the cost of the necessary dust suppression measures run-on/run-off controls, as well as the waste testing and structural stability studies that apply to all facilities under this scenario. For facilities at which potential ground-water contamination is an issue, the model computes the cost of constructing a new landfill, surface impoundment, or gypsum stack containing a single clay or composite liner, or a treatment tank, ground-water monitoring (if applicable), closure costs (composite and soil or rock cap for land disposal units), and financial assurance costs (Note: as discussed above, corrective action costs have not been estimated). Wastes are assumed to be managed in the same manner as they are currently.

One highly significant difference between this scenario and the other two is that under the Subtitle D-Plus program, EPA has assumed that wastes can be sold and used off-site without further processing, e.g., slags could be crushed and sized, then sold for use as road base or construction aggregate. The Agency's data indicate that this constitutes current practice for some wastes at some facilities (i.e., baseline). In these cases, EPA has ascribed current management costs associated with storage, but not for disposal, and has applied this same assumption for the Subtitle D-Plus scenario, i.e., incremental compliance costs for facilities that sell all of their special waste(s) are assumed to be zero under the Subtitle D-Plus program.

Regional/Site Variability

In evaluating the management strategies that would be applied to the special mineral processing wastes under various regulatory scenarios, it is important to consider the substantial variability that exists from site to site with respect to environmental conditions and to the availability of natural materials that may be needed for waste management unit construction. These regional and state-level variations have been taken into consideration in building and applying the cost model, and work in two basic ways: one is in determining the requirements that apply to a given site and the other is in specifying the availability and cost of materials needed to employ a given waste management technology (these two factors are in some cases related).

Waste management requirements are influenced by factors such as net precipitation (i.e., leachate generation potential) and proximity to sensitive environments, such as wetlands. Under all three scenarios, for example, land disposal unit cover requirements are different for facilities in arid areas than they are for facilities located in other areas; landfills and surface impoundments located in the Southwest (e.g., Arizona) are assumed to be capped with a synthetic liner/leachate collection and removal system/rock cap rather than the synthetic liner/clay layer/drainage layer/soil cap required in other areas of the country.

In addition, the techniques and associated costs that are applied to a particular facility are affected by existing regulatory requirements and activities. Facilities that are already permitted Subtitle C Treatment, Storage, and Disposal Facilities (TSDFs) experience only a relatively modest (25 percent of new permit cost) incremental cost associated with opening a new unit rather than the significant permitting costs associated with entering the Subtitle C system for the first time.

Facility location affects material costs in a very direct way if a given scenario requires the installation of a new waste management unit. New units, even under the Subtitle D-Plus scenario, require clay liners, and under the more stringent scenarios, sand layers containing leachate collection systems between liners. In areas where natural clay and/or sand is scarce, this may involve a significant differential cost. EPA has identified the areas (states) in which these materials are not naturally abundant and has factored the extra cost involved in obtaining and transporting them to the site into the cost model. The Agency has assumed that there are no regional cost differentials that apply to man-made materials (e.g., synthetic liner, geosynthetic filter fabric), or to the cost or availability of off-site disposal capacity (for both hazardous and non-hazardous wastes).

Analytical Assumptions

The final step in developing the cost modeling approach is to specify the analytical assumptions that will be applied. Many such assumptions are required, and may affect the outcome of the analysis in significant ways. Wherever possible, EPA has attempted to make important assumptions an input to the cost modeling process, rather than imbed them in the cost modeling computer code. The necessary assumptions and EPA's selected values for numerical variables are presented in the following series of bullets.

- **Operating Life.** EPA has assumed that all new waste management units will be operated (receive wastes) for a period of 15 years, after which they will be closed/ dismantled. For the baseline scenario, the Agency has calculated the cost of current waste management, considering specific controls that may be employed at a particular site (e.g., run-on/run-off controls, ground water monitoring), as well as the expected life of the unit (units projected to close in the near term are replaced in the baseline scenario). For analytical purposes, EPA has assumed that facilities will operate for only the next 15 years. It is worthy of note that after one operational cycle, costs associated with constructing new units will be negligible (in comparison with current costs) at the significant and positive discount rates that have been used in this analysis.
- **Tax Rate.** In order to capture the true cost to the affected firms, EPA has conducted this analysis on an after-tax basis, and has employed a uniform assumption of the maximum federal corporate income tax rate (34.5 percent).
- **Discount Rate.** EPA has used the results of previous work[2] to develop weighted average cost of capital estimates. For this analysis, the Agency has used the overall estimate for all affected industries. In addition, EPA has employed the assumption that affected firms would finance new waste management activities with a combination of debt and equity such that their capital structure remains unchanged, and thus, have the same weighted average cost of capital after compliance as they did prior to the imposition of new regulatory requirements.
- **Inflation Rate.** EPA has conducted this analysis in real terms, i.e., using an inflation rate of zero. This makes the analysis computationally simpler, provides less opportunity for errors in calculation and interpretation, and eliminates the need to make an assumption about a factor that cannot be predicted with any confidence.
- **Sunk Capital.** The Agency has employed the assumption that all of the costs of capital construction of waste management units in the baseline case are unavailable to the firm (i.e., are sunk) as it responds to new regulatory requirements, except if the firm expects to replace its unit(s) during the time horizon of the analysis. In these cases, EPA has incorporated the discounted costs of any new units that will be required in the near-term (as indicated in the SWMPF Survey) into its estimates of current (baseline) waste management costs.

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[2] ICF Incorporated. 1990. Regulatory Impact Analysis for the Proposed Rulemaking on Corrective Action for Solid Waste Management Units (Draft). Prepared for Economic Analysis Staff, Office of Solid Waste, U.S. EPA. June 25.

Appendix E-4

Sources of Market and Financial Data

Appendix E-4
Sources of Market and Financial Data

EPA calculated ratios of estimated compliance costs to value of shipments and value added and the ratio of annualized incremental capital costs to annual sustaining capital expenditures using available industry data. As discussed above, the Agency developed separate compliance cost estimates for waste management under the Subtitle C, C-Minus, and D-Minus scenarios. EPA then divided these facility-level costs by the appropriate facility or company data to arrive at the three measures of economic impact.

In cases where the affected facility produces an intermediate product (e.g., blister copper, pig iron) EPA has used the market value (if available) or estimated transfer price in establishing the value of shipments, and has similarly utilized an estimate of value added that reflects production of the intermediate product. This situation occurs at only a few facilities in a small number of commodity sectors (e.g., the Asarco/Hayden and Phelps Dodge/Playas copper smelters, Asarco's Omaha (refinery) and East Helena (smelter) lead facilities).

To calculate value of shipments (VOS) in all sectors, EPA derived annual long-term production estimates for each facility from data supplied by the United States Bureau of Mines, EPA's 1989 SWMPF Survey, and the SRI Chemical Manufacturers Yearbook.[1] An EPA contractor, Charles River Associates (CRA), supplied estimated long-term (1995) prices for each commodity. EPA converted the estimated price per pound estimated by CRA to a price per metric ton by multiplying by 2,205. Value of shipments is simply the product of annual production and price.

CRA also provided estimates of value added for each sector in 1995. Value added is defined here as the difference between the price of the final mineral commodity and the price (market or transfer) of the mineral input commodity (e.g., ore concentrate, bullion). The Agency recognizes that a true measure of value added would also include the costs of other purchased process inputs (e.g., fuel, reagents), but has relied upon this more simple approach because of data limitations. The value added was estimated in terms of cents-per-pound. EPA converted the cents-per-pound figure into a percentage of value added for each commodity and applied it to each firm's value of shipments to derive a value added estimate. The Agency assumed that all firms within a sector would have a similar cost structure and, therefore, the same percentage of value added.

Investment expenditures for each sector were developed by CRA and reflect estimated sustaining capital costs for average facilities in each affected sector, expressed as annual investment per ton of product. In the lead sector, investments for Doe Run's Boss, MO plant were assumed to be zero because the plant is currently on stand-by status. In the titanium tetrachloride sector, EPA applied the percentage of capital spending to VOS for titanium metals to the Timet plant, while the capital spending to VOS for titanium dioxide was applied to all other plants in the sector.

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[1] 1987 Minerals Yearbook, U.S. Bureau of Mines, 1988; Mineral Commodity Summaries 1989, U.S. Bureau of Mines, 1989; 1987 Directory of Chemical Producers, SRI International, 1987.

Appendix E-5

Results of Financial Impact Analysis

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Copper - Slag																
Entire Sector	17															
Facilities Generating Special Waste	10															
Phelps Dodge - Playas NM		100,000	204,400	1,831	329,694,064	102,177,400	19,841,500	4,610,000	45,312,300	6,761,200	47.6	23.6	2.6%	8.4%	228.4%	34.1%
Copper - Sludge																
Entire Sector	17															
Facilities Generating Special Waste	2															
Kennecott - Garfield UT		210,000	106,577	1,831	384,538,030	118,287,071	23,146,531	9,959,900	33,225,100	4,867,800	47.4	93.5	2.6%	8.4%	143.5%	21.4%
Asarco - Hayden AZ		168,000	33,700	1,831	307,601,100	96,385,667	18,510,826	5,187,200	15,074,600	2,240,300	30.9	153.9	1.7%	5.4%	81.4%	12.1%
SUB-SECTOR TOTAL - SLUDGE		378,000	140,277	1,831	692,170,060	214,672,727	41,657,388	15,147,100	48,299,800	7,208,800	40.1	108.0	2.2%	7.1%	115.9%	17.3%
SECTOR TOTAL - SLAG AND SLUDGE		556,000	504,737	1,831	1,021,774,082	316,780,217	61,508,954	23,757,800	93,611,900	13,969,100	42.6	47.1	2.3%	7.5%	152.2%	22.7%
Ferrous - APC Dust/sludge																
Entire Sector	29															
Iron Facilities Generating Special Waste	20															
LTV Steel - East Cleveland		1,806,000	46,060	198	356,366,132	134,353,174	69,543,002	3,459,400	17,246,400	2,573,250	1.9	74.3	1.0%	2.6%	17.3%	2.6%
Bethlehem Steel - Sparrows Point MD		3,402,040	65,333	198	678,010,080	265,132,168	187,505,365	10,601,000	56,852,100	8,332,800	3.1	160.0	1.6%	4.2%	29.6%	4.4%
U.S. Steel - Fairless Hills PA		1,274,320	33,887	198	252,846,400	84,817,344	70,234,847	87,700	225,000	33,700	0.1	2.0	0.0%	0.1%	0.3%	0.0%
SUB-SECTOR TOTAL		6,482,440	145,300	198	1,290,219,080	482,332,380	357,283,244	14,148,100	73,323,300	10,946,700	2.2	95.3	1.1%	2.9%	20.5%	3.1%
Steel Facilities Generating Special Waste	29															
Sharon Steel - Farrell PA		1,298,200	33,830	529	638,260,829	316,634,016	66,560,607	2,341,700	12,983,000	1,938,700	1.8	69.2	0.4%	0.7%	19.5%	2.9%
U.S. Steel - Lorain OH		2,061,800	58,565	529	1,108,684,968	662,342,483	115,279,684	3,341,200	14,718,800	2,196,800	1.6	57.1	0.3%	0.5%	12.8%	1.9%
SUB-SECTOR TOTAL		3,260,000	92,394	529	1,746,954,794	972,977,387	181,870,291	5,682,900	27,700,800	4,134,800	1.7	61.5	0.3%	0.7%	15.2%	2.3%
SECTOR TOTAL		NA	NA	NA	3,032,174,474	1,355,309,777	539,153,535	19,831,000	101,032,900	15,075,300	NA	NA	0.7%	1.5%	18.7%	2.8%
Hydrofluoric Acid - Process wastewater																
Entire Sector																
Facilities Generating Special Waste																
Allied-Signal - Geismar LA		95,254	6,092,473	1,544	147,072,170	115,451,956	5,248,077	1,758,300	3,428,500	511,800	18.5	0.3	1.2%	1.5%	65.3%	9.7%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Lead																
Entire Sector	6															
Facilities Generating Special Waste	6															
Asarco – East Helena MT	(Unref Pb)	86,000	104,700	303	20,130,670	10,629,672	3,615,586	5,401,700	25,645,600	3,811,700	62.3	51.6	23.3%	48.0%	709.3%	105.4%
Asarco – Glover MO	(Ref'd Pb)	100,000	107,000	887	88,700,000	31,041,000	6,511,016	2,904,000	10,883,100	1,825,400	29.0	29.2	6.6%	8.8%	167.0%	28.0%
Asarco – Omaha NE	(Ref'd Pb)	73,000	8,030	887	37,611,000	11,268,618	4,022,436	1,379,300	129,300	10,300	18.9	171.6	3.7%	12.2%	3.2%	0.3%
Doe Run – Boss MO	(Ref'd Pb)	25,000	11,460	887	12,677,000	8,113,614	1,398,638	1,402,000	3,290,600	489,000	57.0	122.4	11.4%	18.0%	234.3%	35.0%
Doe Run – Herculaneum MO	(Ref'd Pb)	204,000	199,000	887	183,420,000	65,150,640	11,243,572	3,549,300	14,830,400	2,213,800	17.4	17.8	3.4%	5.4%	132.0%	19.7%
SECTOR TOTAL		468,000	430,488	887	237,182,270	127,300,944	26,794,677	14,689,100	54,860,200	8,188,700	31.2	33.9	6.4%	11.5%	212.0%	31.0%
Magnesium																
Entire Sector	3															
Facilities Generating Special Waste	1															
Magcorp – Rowley UT		27,370	2,329,004	3,609	98,579,000	98,579,000	3,017,576	1,231,000	1,887,000	269,100	45.0	0.5	1.2%	1.2%	62.5%	8.9%
Phosphoric Acid – Phosphogypsum																
Entire Sector	21															
Facilities Generating Special Waste	21															
AgriChem – Fort Meade FL		524,000	2,369,000	662	346,888,000	312,109,200	14,440,274	17,310,300	90,894,200	13,540,400	33.0	7.3	5.0%	5.5%	629.8%	93.8%
Agrico Chemical – Mulberry FL		498,000	2,580,000	662	329,670,000	299,768,400	13,723,772	41,395,000	220,517,000	32,904,000	83.1	16.0	12.6%	13.8%	1606.8%	239.8%
Agrico Chemical – Uncle Sam LA		530,000	4,050,679	662	549,499,000	404,514,000	22,872,050	68,794,000	534,300,000	79,737,100	129.2	21.3	18.2%	20.2%	2336.3%	348.6%
Central Phosphates – Plant City FL		868,000	4,316,000	662	571,290,000	514,178,400	23,752,380	186,042,000	984,320,100	147,023,380	214.4	42.8	32.4%	36.0%	4143.1%	618.2%
Chevron – Rock Springs WY		291,000	1,300,918	662	192,842,000	173,377,000	8,818,312	10,900,100	68,315,000	9,403,000	37.4	8.3	5.7%	6.3%	782.3%	104.8%
Gardinier – Riverview FL		614,000	2,879,190	662	400,488,000	365,621,200	16,025,474	117,100,700	621,514,600	88,737,800	190.7	40.4	29.8%	32.0%	3873.2%	548.1%
Mobil Mining – Pasadena TX		332,000	1,227,404	662	219,704,000	197,888,000	9,148,151	46,888,000	247,207,200	36,888,400	141.1	38.2	21.3%	23.7%	2702.0%	403.2%
Nu-South Industries – Pascagoula MS		240,000	1,282,430	662	164,520,000	140,264,200	6,861,488	60,429,200	330,400,400	49,298,000	250.7	46.5	37.0%	42.1%	4815.0%	718.5%
Nu-West – Soda Springs ID		332,000	1,553,720	662	219,704,000	197,906,000	9,148,151	11,988,400	62,748,000	9,362,600	36.1	7.7	5.5%	6.1%	685.9%	102.3%
Occidental Chemical – White Springs FL		942,000	4,387,900	662	648,480,000	580,906,000	26,900,631	27,711,000	140,070,100	22,244,800	29.4	6.3	4.3%	4.8%	554.0%	82.8%
Royster – Palmetto FL		266,000	1,316,700	662	176,082,000	158,482,800	7,330,380	64,114,800	338,883,200	50,542,000	241.0	48.7	36.4%	40.6%	4624.0%	689.6%
SUB-SECTOR TOTAL		5,774,000	27,588,828	662	3,822,388,000	3,440,148,700	159,115,582	684,568,400	3,637,294,500	542,729,800	118.6	24.8	17.9%	19.9%	2285.9%	341.1%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Phosphoric Acid – Process Wastewater																
Entire Sector	21															
Facilities Generating Special Waste	21															
Agrichem – Fort Meade FL		824,000	71,832,160	[illegible]	348,000,000	312,[illegible],200	14,440,274	5,848,900	15,487,700	2,311,000	11.2	0.1	1.7%	1.9%	107.2%	16.0%
Agrico Chemical – Donaldsonville LA		600,000	114,702,776	[illegible]	368,670,000	308,200,400	10,470,540	12,131,100	25,212,800	5,851,000	20.3	0.1	3.1%	3.4%	237.9%	38.0%
Agrico Chemical – Mulberry FL		408,000	127,801,576	[illegible]	350,070,000	288,700,400	13,723,773	11,007,900	32,239,300	4,810,800	22.3	0.1	3.4%	3.7%	234.9%	35.1%
Agrico Chemical – Uncle Sam LA		839,000	169,083,280	[illegible]	840,480,000	404,514,000	22,072,053	15,540,700	50,320,800	7,600,800	18.7	0.1	2.8%	3.1%	220.9%	32.8%
Arcadian – Geismar LA		221,000	49,387,380	[illegible]	148,292,000	131,871,800	8,080,200	5,376,000	18,100,100	2,414,380	24.3	0.1	3.7%	4.1%	298.7%	39.8%
Central Phosphates – Plant City FL		863,000	183,848,288	[illegible]	871,200,000	814,176,400	23,752,389	22,313,100	68,915,100	10,283,000	25.8	0.1	3.9%	4.3%	289.8%	43.2%
CF Chemicals – Bartow FL		169,000	42,027,074	[illegible]	160,098,000	[illegible],082,600	4,674,081	6,840,800	19,420,100	2,800,100	41.9	0.1	6.3%	7.0%	424.9%	60.4%
Chevron – Rock Springs WY		281,000	23,113,002	[illegible]	182,842,800	173,377,900	8,819,312	4,700,160	12,438,400	1,850,100	18.4	0.1	2.5%	2.7%	158.1%	23.1%
Conserv – Nichols FL		274,000	38,291,724	[illegible]	181,300,000	163,249,200	7,550,630	3,213,380	8,053,800	1,194,200	11.7	0.1	1.8%	2.0%	108.0%	15.8%
Farmland Industries – Bartow FL		684,000	87,258,232	[illegible]	420,908,000	386,611,200	10,288,383	8,818,900	18,332,300	2,726,480	10.3	0.1	1.6%	1.7%	100.2%	14.9%
Gardinier – Riverview FL		814,000	128,917,800	[illegible]	408,480,000	368,621,200	18,020,474	18,844,100	81,094,100	7,623,800	20.9	0.1	4.1%	4.5%	202.0%	48.1%
IMC Fertilizer – Mulberry FL		1,705,000	352,465,570	[illegible]	1,100,000,000	1,089,289,400	40,411,000	29,300,200	79,008,700	11,787,700	14.7	0.1	2.2%	2.5%	180.0%	23.8%
Mobil Mining – Pasadena TX		332,000	69,807,204	[illegible]	219,794,000	197,895,600	9,149,181	5,623,300	34,179,100	3,807,800	24.2	0.1	3.7%	4.1%	284.3%	38.4%
Nu-South Industries – Pascagoula MS		240,000	45,189,970	[illegible]	184,630,000	148,384,200	8,601,880	7,070,700	29,091,200	3,883,100	31.8	0.2	4.6%	5.3%	360.2%	58.7%
Nu-West – Soda Springs ID		332,000	69,807,304	[illegible]	219,794,000	197,806,800	9,140,181	5,742,000	19,423,800	2,480,000	17.3	0.1	2.6%	2.8%	170.5%	28.6%
Occidental Chemical – White Springs FL		975,000	177,088,880	[illegible]	648,480,000	880,805,030	29,908,431	12,799,100	38,698,200	5,498,000	13.1	0.1	2.0%	2.2%	137.2%	20.5%
Royster – Mulberry FL		380,000	72,843,756	[illegible]	283,470,000	237,125,400	10,087,894	6,506,800	17,001,000	2,871,100	18.3	0.1	2.5%	2.7%	182.2%	24.4%
Royster – Palmetto FL		288,000	69,840,462	[illegible]	179,088,000	156,402,000	7,330,380	10,718,600	39,137,000	5,382,100	40.3	0.2	6.1%	6.6%	483.0%	73.9%
Seminole Fertilizer – Bartow FL		672,000	116,468,720	[illegible]	444,084,000	400,377,000	18,518,828	12,047,700	37,188,800	5,548,000	19.3	0.1	2.6%	3.2%	200.8%	30.0%
JR Simplot – Pocatello ID		329,000	59,802,172	[illegible]	218,012,000	194,230,800	8,083,836	5,309,200	14,958,200	2,231,000	19.5	0.1	2.5%	2.6%	180.5%	24.8%
Texasgulf – Aurora NC		1,394,000	148,840,380	[illegible]	902,000,000	812,871,200	37,569,906	18,168,300	62,188,700	9,279,300	13.3	0.1	2.0%	2.2%	166.4%	24.7%
SUB-SECTOR TOTAL		12,250,000	2,279,724,580	[illegible]	8,100,000,000	7,288,840,000	337,962,742	229,033,100	682,629,000	101,800,000	18.4	0.1	2.8%	3.1%	202.2%	30.2%
SECTOR TOTAL – PWW AND PHSGYP		8,774,000	2,268,321,182	[illegible]	3,622,300,000	3,440,140,200	190,118,082	909,621,500	4,318,623,500	644,588,900	187.5	0.4	23.8%	26.4%	2714.9%	408.1%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Titanium Tetrachloride																
Entire Sector	9															
Facilities Generating Special Waste	9															
Dupont – New Johnsonville TN	(TiO2)	249,476	119,180	2,205	550,000,000	909,000,000	27,800,000	9,496,800	33,218,800	4,958,400	38.1	79.7	1.7%	1.0%	120.0%	18.0%
SCM Chemicals – Ashtabula OH	(TiO2)	107,048	61,128	2,205	236,000,000	186,440,000	11,800,000	6,993,000	26,008,000	3,904,800	66.9	117.1	2.9%	3.2%	220.2%	33.0%
Kerr-McGee – Hamilton MS	(TiO2)	77,111	37,062	2,205	170,000,000	124,200,000	8,800,000	5,448,100	16,044,800	2,400,200	70.7	147.0	3.2%	4.1%	182.3%	27.3%
Timet – Henderson NV	(Metal)	12,701	50,490	11,023	140,000,000	134,120,000	7,600,000	7,134,400	22,981,200	3,428,100	561.7	141.3	5.1%	5.3%	276.3%	46.0%
SECTOR TOTAL		NA	267,884	NA	1,096,000,000	900,000,000	56,200,000	29,084,200	98,252,800	14,790,200	NA	108.9	2.6%	2.0%	180.4%	26.0%
Zinc																
Entire Sector	4															
Facilities Generating Special Waste	1															
Zinc Corp of Amer – Monaca PA		72,800	126,044	1,323	96,314,400	43,341,450	7,222,342	4,821,800	21,977,500	3,278,300	67.8	38.1	5.1%	11.4%	304.3%	45.4%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C-MINUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Copper – Slag																
Entire Sector	17															
Facilities Generating Special Waste	10															
Phelps Dodge – Playas NM		180,000	364,400	1,831	329,604,804	162,177,480	19,841,586	1,078,800	2,423,800	361,600	6.0	3.0	0.3%	1.1%	12.2%	1.8%
Copper – Sludge																
Entire Sector	17															
Facilities Generating Special Waste	2															
Kennecott – Garfield UT		210,000	106,577	1,831	384,528,020	119,207,071	23,148,531	1,182,100	3,588,500	536,400	5.6	11.1	0.3%	1.0%	15.5%	2.3%
Asarco – Hayden AZ		168,000	33,700	1,831	307,651,150	96,365,667	18,518,825	453,000	511,000	78,400	2.7	13.4	0.1%	0.5%	2.8%	0.4%
SUB-SECTOR TOTAL – SLUDGE		378,000	140,277	1,831	692,179,080	214,672,727	41,667,356	1,635,100	4,100,400	611,000	4.3	11.7	0.2%	0.8%	9.8%	1.5%
SECTOR TOTAL – SLAG AND SLUDGE		558,000	504,737	1,831	1,021,774,080	316,780,217	61,508,984	2,711,900	6,524,000	973,400	4.9	5.4	0.3%	0.9%	10.6%	1.6%
Ferrous – APC Dust/Sludge																
Entire Sector	20															
Iron Facilities Generating Special Waste	20															
LTV Steel – East Cleveland OH		1,809,080	48,058	199	360,360,132	134,353,174	99,543,082	1,624,600	8,748,800	1,008,000	0.9	34.8	0.5%	1.2%	8.8%	1.0%
Bethlehem Steel – Sparrows Point MD		2,629,200	80,333	199	521,470,070	196,563,620	144,564,088	4,629,100	22,012,700	3,294,000	1.8	57.7	0.9%	2.4%	15.2%	2.3%
U.S. Steel – Fairless Hills PA		1,272,000	33,007	199	252,070,000	94,716,642	70,160,880	67,000	225,000	33,700	0.1	2.0	0.0%	0.1%	0.3%	0.0%
SUB-SECTOR TOTAL		5,707,240	148,398	199	1,132,097,013	424,052,656	314,567,970	6,318,200	28,988,500	4,329,200	1.1	42.6	0.6%	1.5%	9.2%	1.4%
Steel Facilities Generating Special Waste	20															
Sharon Steel – Farrell PA		1,200,300	33,639	529	635,137,000	319,569,000	69,560,807	935,000	5,089,000	781,000	0.8	27.7	0.1%	0.3%	7.7%	1.1%
U.S. Steel – Lorain OH		2,061,600	38,085	529	1,109,408,400	553,228,290	116,279,084	1,080,300	5,395,000	809,600	0.5	28.7	0.2%	0.3%	4.7%	0.7%
SUB-SECTOR TOTAL		3,260,000	72,304	529	1,744,604,200	872,797,190	181,879,291	2,015,300	10,484,000	1,591,600	0.6	28.3	0.1%	0.2%	5.8%	0.9%
SECTOR TOTAL		NA	NA	NA	2,876,901,818	1,297,449,856	496,427,081	8,334,100	39,451,400	5,880,700	NA	NA	0.3%	0.7%	7.9%	1.2%
Hydrofluoric Acid – Process wastewater																
Entire Sector	3															
Facilities Generating Special Waste	3															
Allied-Signal – Geismar LA		95,254	6,082,473	1,544	147,072,176	116,451,058	5,248,877	1,685,900	3,049,000	454,400	17.7	0.3	1.1%	1.5%	58.0%	8.7%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C-MINUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Lead																
Entire Sector	5															
Facilities Generating Special Waste	5															
Asarco - East Helena MT	(Unref Pb)	65,600	104,763	352	23,136,576	9,629,672	3,616,600	2,866,200	11,399,100	1,700,300	44.1	27.8	12.0%	29.7%	315.2%	47.0%
Asarco - Glover MO	(Ref'd Pb)	100,000	107,000	507	50,700,000	31,041,000	5,511,568	2,418,600	8,711,200	1,269,800	24.2	22.6	4.8%	7.8%	158.1%	23.0%
Asarco - Omaha NE	(Ref'd Pb)	73,000	8,036	507	37,011,000	11,200,618	4,023,436	1,380,800	181,200	28,500	18.9	173.2	3.6%	12.3%	4.5%	0.7%
Doe Run - Buick MO	(Ref'd Pb)	25,400	11,963	507	12,877,800	8,113,014	1,355,636	1,148,400	1,504,300	231,800	45.2	96.0	8.9%	14.2%	111.0%	16.8%
Doe Run - Herculaneum MO	(Ref'd Pb)	204,000	199,096	507	103,428,000	66,100,840	11,243,672	839,000	2,074,800	309,800	4.1	4.2	0.8%	1.3%	18.5%	2.8%
SECTOR TOTAL		468,000	430,452	487	227,152,376	127,300,044	25,794,077	8,653,700	23,826,400	3,578,100	18.8	20.2	3.8%	6.8%	92.8%	13.8%
Magnesium																
Entire Sector	3															
Facilities Generating Special Waste	1															
Magcorp - Rowley UT		27,376	2,326,064	3,620	99,579,000	99,579,000	2,017,670	1,182,200	1,087,800	248,800	43.2	0.5	1.2%	1.2%	56.3%	8.2%
Phosphoric Acid - Phosphogypsum																
Entire Sector	21															
Facilities Generating Special Waste	21															
Agrichem - Fort Meade FL		524,000	2,368,000	662	346,888,000	312,189,200	14,440,274	11,788,600	60,180,800	8,887,800	22.4	5.0	3.4%	3.8%	416.2%	62.1%
Agrico Chemical - Mulberry FL		498,000	2,626,000	662	329,676,000	299,700,400	13,723,772	20,456,000	110,617,400	16,460,300	41.1	7.8	6.2%	6.8%	806.2%	120.0%
Agrico Chemical - Uncle Sam LA		830,000	4,986,670	662	549,460,000	494,514,000	22,872,063	65,380,000	343,514,600	51,268,700	78.7	13.0	11.9%	13.2%	1501.8%	224.1%
Central Phosphates - Plant City FL		863,000	4,316,000	662	571,306,000	514,176,400	23,782,300	30,179,700	164,700,000	24,578,300	35.0	7.0	5.3%	5.9%	692.5%	103.3%
Chevron - Rock Springs WY		291,000	1,300,618	662	192,642,000	173,377,800	6,019,312	1,276,300	2,000,200	482,300	4.4	1.0	0.7%	0.7%	33.0%	8.0%
Gardinier - Riverview FL		614,000	2,578,100	662	406,468,000	365,621,200	16,920,474	21,400,400	114,562,400	17,094,100	34.9	8.3	5.3%	5.9%	677.1%	101.0%
Mobil Mining - Pasadena TX		332,000	1,227,404	662	219,784,000	197,086,800	9,140,181	12,878,600	68,186,400	10,178,100	38.8	10.5	5.9%	6.5%	746.4%	111.2%
Nu-South Industries - Pascagoula MS		249,000	1,262,420	662	164,838,000	148,384,200	6,801,588	13,079,800	68,336,600	10,248,700	52.5	10.4	7.9%	8.8%	1010.4%	150.8%
Nu-West - Soda Springs ID		332,000	1,563,720	662	219,784,000	197,096,800	9,140,181	8,063,100	41,054,700	6,128,800	24.3	5.2	3.7%	4.1%	448.7%	67.0%
Occidental Chemical - White Springs FL		975,000	4,187,000	662	645,450,000	560,905,000	26,968,831	18,018,100	100,310,100	14,987,500	18.4	4.3	2.8%	3.3%	373.3%	55.7%
Royster - Palmetto FL		266,000	1,316,700	662	176,092,000	158,482,800	7,330,388	13,361,600	70,714,700	10,551,500	50.2	10.1	7.6%	8.4%	964.7%	143.9%
SUB-SECTOR TOTAL		5,774,000	27,586,820	662	3,822,388,000	3,440,149,200	159,118,562	218,738,200	1,146,104,900	171,013,200	37.5	7.9	5.7%	6.3%	720.3%	107.5%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C-MINUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Phosphoric Acid - Process Wastewater	(SLUDGE NOT TOXIC)															
Entire Sector	21															
Facilities Generating Special Waste	21															
Agrichem - Fort Meade FL		524,000	71,832,190	662	346,888,000	312,199,200	14,440,274	5,537,300	13,790,500	2,066,200	10.6	0.1	1.6%	1.8%	86.4%	14.2%
Agrico Chemical - Donaldsonville LA		605,000	114,702,770	662	400,510,000	360,459,000	10,470,540	11,879,500	38,708,000	6,477,300	19.6	0.1	2.9%	3.3%	222.7%	33.2%
Agrico Chemical - Mulberry FL		488,000	127,901,870	662	323,056,000	290,750,400	13,725,772	10,004,300	29,788,400	4,440,900	21.4	0.1	3.2%	3.6%	217.1%	32.4%
Agrico Chemical - Uncle Sam LA		830,000	190,083,200	662	549,460,000	494,514,000	22,672,052	14,874,500	47,183,400	7,041,800	18.0	0.1	2.7%	3.0%	208.3%	30.8%
Arcadian - Geismar LA		221,000	40,337,300	662	146,302,000	131,671,800	6,080,268	5,161,700	15,021,800	2,241,400	23.4	0.1	3.5%	3.9%	248.7%	36.8%
Central Phosphates - Plant City FL		863,000	163,840,380	662	571,306,000	514,175,400	23,762,380	21,060,100	62,067,300	9,260,900	24.4	0.1	3.7%	4.1%	260.0%	38.9%
CF Chemicals - Bartow FL		166,000	82,027,674	662	109,892,000	98,902,800	4,674,801	6,610,200	17,577,700	2,622,900	39.8	0.1	6.0%	6.7%	364.2%	57.2%
Chevron - Rock Springs WY		291,000	53,113,902	662	192,642,000	173,377,800	8,019,312	4,554,400	11,043,100	1,647,900	15.6	0.1	2.3%	2.6%	137.7%	20.5%
Conserv - Nichols FL		274,000	38,201,724	662	181,388,000	163,249,200	7,550,530	3,046,400	7,110,300	1,060,900	11.1	0.1	1.7%	1.9%	94.2%	14.1%
Farmland Industries - Bartow FL		664,000	67,250,232	662	439,568,000	395,611,200	18,290,364	6,404,750	16,399,300	2,447,000	9.7	0.1	1.5%	1.6%	89.6%	13.4%
Gardinier - Riverview FL		614,000	128,817,880	662	406,468,000	365,821,200	16,920,474	16,032,900	46,040,600	6,870,700	26.6	0.1	3.9%	4.3%	272.1%	40.6%
IMC Fertilizer - Mulberry FL		1,780,000	352,488,579	662	1,178,360,000	1,060,524,000	48,411,080	25,516,900	75,230,900	11,226,100	14.3	0.1	2.2%	2.4%	152.3%	22.7%
Mobil Mining - Pasadena TX		332,000	60,667,304	662	219,784,000	197,805,600	9,148,181	7,657,200	22,067,900	3,292,900	23.0	0.1	3.5%	3.9%	241.2%	36.0%
Nu-South Industries - Pascagoula MS		249,000	45,106,575	662	164,838,000	148,354,200	6,861,600	7,461,100	24,613,300	3,662,100	30.1	0.2	4.5%	5.0%	360.0%	53.2%
Nu-West - Soda Springs ID		332,000	60,667,304	662	219,784,000	197,805,600	9,148,181	6,462,700	14,899,800	2,223,100	19.5	0.1	2.9%	3.3%	162.9%	24.3%
Occidental Chemical - White Springs FL		975,000	177,068,960	662	645,450,000	580,905,000	26,680,631	12,250,000	33,011,500	5,060,000	12.6	0.1	1.9%	2.1%	120.2%	18.8%
Royster - Mulberry FL		398,000	72,643,798	662	263,476,000	237,128,400	10,667,694	6,108,300	16,163,400	2,414,900	15.6	0.1	2.4%	2.6%	147.6%	22.0%
Royster - Palmetto FL		263,000	88,640,468	662	174,106,000	156,695,400	7,330,209	10,108,800	33,292,200	4,963,100	38.3	0.2	5.8%	6.4%	453.9%	67.7%
Seminole Fertilizer - Bartow FL		672,000	169,409,730	662	444,864,000	400,377,600	16,616,625	12,434,100	34,308,900	5,120,330	18.5	0.1	2.8%	3.1%	188.9%	27.7%
JR Simplot - Pocatello ID		326,000	89,602,172	662	215,812,000	194,230,800	8,962,638	5,083,000	13,481,800	2,007,100	15.6	0.1	2.4%	2.6%	149.7%	22.3%
Texasgulf - Aurora NC		1,364,000	140,040,300	662	902,968,000	812,671,200	37,568,606	17,262,900	57,863,100	8,636,400	12.6	0.1	1.9%	2.1%	154.0%	23.0%
SUB-SECTOR TOTAL		12,250,000	2,270,724,626	662	8,109,500,000	7,298,550,000	337,582,742	216,120,900	625,006,700	93,706,300	17.6	0.1	2.7%	2.9%	185.0%	27.8%
SECTOR TOTAL - PWW AND PHSGYP		5,774,000	2,280,321,152	662	3,822,388,000	3,440,149,200	150,116,582	431,880,100	1,774,111,800	264,718,800	74.8	0.2	11.3%	12.6%	1116.9%	169.4%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE C-MINUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Titanium Dioxide																
Entire Sector	9															
Facilities Generating Special Waste	9															
Dupont – New Johnsonville TN	(TiO2)	248,470	118,188	2,200	550,000,000	500,000,000	27,500,000	141,700	7,913,800	1,180,900	0.6	1.2	0.0%	0.0%	28.8%	4.3%
SCM Chemicals – Ashtabula OH	(TiO2)	107,640	51,130	2,200	230,000,000	186,440,000	11,800,000	623,300	7,206,600	1,076,100	5.8	12.2	0.3%	0.3%	61.1%	9.1%
Kerr-McGee – Hamilton MS	(TiO2)	77,111	37,020	2,200	170,000,000	134,380,000	8,500,000	988,800	3,018,400	450,400	11.6	24.3	0.6%	0.7%	35.5%	5.2%
Timet – Henderson NV	(Metal)	12,701	50,480	11,623	140,000,000	134,120,000	7,000,000	1,544,800	6,644,600	991,800	121.6	30.6	1.1%	1.2%	94.9%	14.2%
SECTOR TOTAL		NA	257,584	NA	1,090,000,000	980,000,000	54,800,000	3,298,700	24,782,700	3,697,800	NA	12.4	0.3%	0.3%	45.2%	6.7%
Zinc																
Entire Sector	4															
Facilities Generating Special Waste	1															
Zinc Corp of Amer – Monaca PA		72,860	125,944	1,323	98,314,480	43,341,480	7,222,342	1,377,100	3,717,000	554,800	18.9	10.9	1.4%	3.2%	51.5%	7.7%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE D-PLUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Copper - Slag																
Entire Sector	17															
Facilities Generating Special Waste	10															
Phelps Dodge - Playas NM		180,000	364,460	1,831	329,656,000	102,177,400	19,841,000	471,300	968,800	144,700	2.6	1.3	0.1%	0.5%	4.9%	0.7%
Copper - Sludge																
Entire Sector	17															
Facilities Generating Special Waste	2															
Kennecott - Garfield UT		210,000	106,577	1,831	384,510,000	118,307,071	23,148,531	704,200	2,567,000	383,000	3.4	6.6	0.2%	0.6%	11.1%	1.7%
Asarco - Hayden AZ		168,000	33,700	1,831	307,608,000	96,365,656	18,518,826	309,900	370,300	55,300	1.8	9.2	0.1%	0.3%	2.0%	0.3%
SUB-SECTOR TOTAL - SLUDGE		378,000	140,277	1,831	692,118,000	214,672,727	41,667,358	1,014,100	2,937,300	438,300	2.7	7.2	0.1%	0.5%	7.0%	1.1%
SECTOR TOTAL - SLAG AND SLUDGE		558,000	504,737	1,831	1,021,774,000	316,850,127	61,508,364	1,485,400	3,906,100	583,000	2.7	NA	0.1%	0.5%	6.4%	0.9%
Ferrous - APC Dust/sludge																
Entire Sector	25															
Facilities Generating Special Waste	20															
LTV Steel - East Cleveland OH		1,826,000	46,668	188	358,358,122	134,283,174	96,843,082	1,624,500	7,748,000	1,006,800	0.9	34.8	0.5%	1.2%	8.0%	1.0%
Bethlehem Steel - Sparrows Point MD		2,820,300	68,333	188	531,470,870	190,855,029	144,864,059	4,625,600	22,012,700	3,284,800	1.6	67.7	0.9%	2.4%	15.2%	2.3%
U.S. Steel - Fairless Hills PA		1,272,000	33,887	188	242,578,821	94,718,852	70,180,000	60,000	228,000	33,700	0.0	1.8	0.0%	0.1%	0.3%	0.0%
SUB-SECTOR TOTAL		5,767,240	148,888	188	1,132,407,813	424,052,044	314,887,870	6,310,100	29,988,700	4,325,300	1.1	42.6	0.6%	1.5%	9.2%	1.4%
Facilities Generating Special Waste	20															
Sharon Steel - Farrell PA		1,206,200	33,530	529	638,137,800	310,580,000	68,560,807	928,800	5,069,600	781,000	0.8	27.7	0.1%	0.3%	7.7%	1.1%
U.S. Steel - Lorain OH		2,091,000	65,854	529	1,106,469,400	663,229,200	115,270,084	1,886,200	5,398,600	800,880	0.9	28.7	0.2%	0.3%	4.7%	0.7%
SUB-SECTOR TOTAL		3,297,200	99,384	529	1,744,607,200	973,797,180	183,830,891	2,815,000	10,468,200	1,581,880	0.9	28.3	0.1%	0.3%	5.6%	0.9%
SECTOR TOTAL		NA	NA	NA	2,877,015,013	1,397,448,086	498,427,881	9,125,100	39,451,400	5,906,700	NA	NA	0.3%	0.7%	7.9%	1.2%
Hydrofluoric Acid - Process wastewater																
Entire Sector	3															
Facilities Generating Special Waste	3															
Allied-Signal - Geismar LA		95,254	6,062,473	1,544	147,072,176	116,451,868	5,248,877	1,563,100	3,045,800	454,400	16.4	0.3	1.1%	1.3%	58.0%	8.7%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE D-PLUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Lead																
Entire Sector	5															
Facilities Generating Special Waste	5															
Asarco – East Helena MT	(Unref Pb)	68,600	104,763	353	23,136,576	10,629,672	3,616,580	2,896,200	11,396,100	1,700,300	44.1	27.6	12.5%	26.7%	315.2%	47.0%
Asarco – Glover MO	(Ref'd Pb)	100,000	107,000	887	88,700,000	31,941,000	5,511,560	2,019,300	7,617,000	1,130,600	20.2	18.9	4.6%	6.3%	138.2%	20.6%
Asarco – Omaha NE	(Ref'd Pb)	73,000	8,030	887	37,611,000	11,395,610	4,623,426	1,362,700	3,874,700	646,300	18.6	169.6	3.7%	12.0%	81.3%	13.6%
Doe Run – Boss MO	(Ref'd Pb)	26,400	11,983	887	12,677,000	5,113,614	1,396,606	744,000	1,930,200	298,000	28.3	62.2	5.8%	6.2%	138.3%	20.6%
Doe Run – Herculaneum MO	(Ref'd Pb)	204,000	199,088	887	183,429,000	69,169,040	11,243,672	571,100	1,794,000	291,700	2.8	2.9	0.6%	0.8%	16.0%	2.3%
SECTOR TOTAL		488,000	430,453	887	227,152,376	127,308,944	26,794,077	7,660,300	26,377,000	3,636,600	16.2	17.6	3.3%	6.0%	102.3%	16.3%
Magnesium																
Entire Sector	3															
Facilities Generating Special Waste	1															
Magcorp – Rowley UT		27,376	2,328,654	3,529	96,679,000	96,679,000	3,017,679	1,163,200	1,687,800	248,000	43.2	0.5	1.2%	1.2%	56.3%	8.2%
Phosphoric Acid – Phosphogypsum																
Entire Sector	21															
Facilities Generating Special Waste	21															
Agrichem – Fort Meade FL		524,000	2,388,000	682	348,688,000	312,189,200	14,440,274	11,644,000	64,067,100	9,559,800	22.2	4.9	3.4%	3.7%	443.7%	66.2%
Agrico Chemical – Mulberry FL		486,000	2,580,000	682	320,676,000	296,766,400	13,723,772	11,885,600	66,827,300	9,941,800	23.9	4.6	3.6%	4.0%	486.9%	72.4%
Agrico Chemical – Uncle Sam LA		830,000	4,696,670	682	846,460,000	494,514,200	22,672,653	62,241,800	362,293,600	52,093,200	75.0	13.3	11.3%	12.6%	1597.9%	229.8%
Central Phosphates – Plant City FL		862,000	4,318,000	682	571,308,000	514,175,400	23,782,380	17,888,000	101,202,800	15,100,700	20.7	4.1	3.1%	3.5%	425.5%	63.5%
Chevron – Rock Springs WY		281,000	1,308,816	682	192,042,000	173,377,800	8,619,312	483,100	874,700	130,000	1.7	0.4	0.3%	0.3%	10.1%	1.5%
Gardinier – Riverview FL		614,000	2,578,100	682	408,468,000	388,821,200	16,929,474	12,750,000	70,181,200	10,489,800	20.8	4.9	3.1%	3.3%	414.7%	61.9%
Mobil Mining – Pasadena TX		332,000	1,227,404	682	218,764,000	197,855,800	9,149,181	7,427,700	40,068,000	5,877,200	22.4	6.1	3.4%	3.8%	437.9%	64.2%
Nu-South Industries – Pascagoula MS		248,000	1,262,430	682	164,836,000	149,384,200	6,961,000	7,414,100	40,256,400	6,058,000	29.9	5.9	4.5%	5.0%	578.3%	87.0%
Nu-West – Soda Springs ID		332,000	1,683,720	682	218,764,000	197,805,800	9,146,181	7,980,300	41,084,700	6,125,000	24.0	5.1	3.6%	4.0%	449.2%	67.0%
Occidental Chemical – White Springs FL		978,000	4,367,000	682	649,450,000	580,909,000	26,866,531	18,913,300	100,310,100	14,867,000	19.3	4.3	2.9%	3.2%	373.3%	55.3%
Royster – Palmetto FL		290,000	1,316,700	682	179,082,000	158,462,800	7,330,388	7,981,000	41,487,000	6,190,000	28.8	6.0	4.4%	4.9%	566.1%	84.4%
SUB-SECTOR TOTAL		5,774,000	27,999,029	682	3,622,398,000	3,440,149,200	159,118,660	189,188,200	918,313,200	137,023,700	28.6	6.0	4.2%	4.8%	577.1%	86.1%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE D-PLUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital costs/capital investments (percent)	Annual capital costs/capital investments (percent)
Phosphoric Acid – Process Wastewater																
Entire Sector	21															
Facilities Generating Special Waste	21															
AgriChem – Fort Meade FL		524,000	71,932,199	662	346,888,000	312,199,200	14,440,274	8,434,400	13,790,500	2,098,200	16.4	0.1	1.8%	1.7%	95.5%	14.7%
Agrico Chemical – Donaldsonville LA		586,000	114,792,779	662	386,070,000	350,256,400	18,479,840	11,879,500	39,706,000	5,977,300	19.5	0.1	2.0%	3.3%	222.7%	32.7%
Agrico Chemical – Mulberry FL		496,000	107,891,676	662	328,370,000	295,708,400	13,723,772	10,561,400	29,795,400	4,445,800	21.2	0.1	3.2%	3.6%	217.1%	32.4%
Agrico Chemical – Uncle Sam LA		936,000	190,883,289	662	619,480,000	484,514,000	22,572,063	14,871,800	47,183,400	7,041,800	17.8	0.1	2.7%	3.0%	209.3%	30.8%
Arcadian – Geismar LA		221,000	46,327,380	662	146,302,000	131,671,800	8,080,208	8,060,600	18,021,800	2,241,400	22.8	0.1	3.3%	3.8%	248.7%	36.8%
Central Phosphates – Plant City FL		860,000	153,045,282	662	571,290,000	514,179,600	23,792,380	21,080,100	62,667,500	8,280,800	24.4	0.1	3.7%	4.1%	280.6%	38.6%
CF Chemicals – Bartow FL		165,000	82,627,674	662	109,228,000	98,302,400	4,674,561	6,067,400	17,677,700	2,622,900	38.2	0.1	5.6%	6.8%	384.2%	57.3%
Chevron – Rock Springs WY		291,000	63,113,903	662	192,642,000	173,377,800	8,018,312	4,401,800	11,042,100	1,647,800	15.1	0.1	2.3%	2.5%	137.7%	20.5%
Conserv – Nichols FL		274,000	25,201,724	662	181,388,000	163,249,200	7,550,630	2,943,000	7,110,300	1,060,800	10.8	0.1	1.6%	1.8%	94.2%	14.1%
Farmland Industries – Bartow FL		664,000	57,290,232	662	439,568,000	395,611,200	18,290,303	6,381,800	16,380,200	2,447,000	9.6	0.1	1.4%	1.6%	89.6%	13.4%
Gardinier – Riverview FL		614,000	128,617,800	662	406,468,000	365,821,200	16,929,474	15,529,800	46,040,800	6,870,700	25.3	0.1	3.8%	4.2%	272.1%	40.6%
IMC Fertilizer – Mulberry FL		1,702,000	362,468,679	662	1,126,924,000	1,096,280,400	48,411,000	26,016,000	78,236,800	11,226,100	14.2	0.1	2.1%	2.4%	162.2%	22.7%
Mobil Mining – Pasadena TX		332,000	69,867,394	662	219,784,000	197,806,800	8,149,181	7,534,800	22,067,900	3,290,800	22.7	0.1	3.4%	3.8%	241.2%	36.0%
Nu-South Industries – Pascagoula MS		249,000	48,186,676	662	164,838,000	148,354,200	6,861,600	7,389,200	24,613,300	3,662,100	29.7	0.2	4.5%	5.0%	360.0%	53.2%
Nu-West – Soda Springs ID		332,000	60,087,394	662	219,784,000	197,806,800	8,149,181	6,380,800	14,896,800	2,223,100	19.1	0.1	2.9%	2.7%	182.8%	24.3%
Occidental Chemical – White Springs FL		970,000	177,080,890	662	642,140,000	580,036,000	26,699,611	12,152,100	33,611,500	5,080,000	12.6	0.1	1.9%	2.1%	126.2%	18.8%
Royster – Mulberry FL		380,000	73,943,700	662	252,476,000	227,128,400	10,087,984	6,088,400	16,163,600	2,414,800	16.3	0.1	2.3%	2.6%	167.6%	22.0%
Royster – Palmetto FL		269,000	68,949,466	662	178,082,000	158,462,000	7,330,205	10,094,000	32,252,200	4,980,100	37.6	0.2	5.7%	6.4%	462.8%	67.7%
Seminole Fertilizer – Bartow FL		673,000	149,490,738	662	444,884,000	400,377,600	18,616,875	12,331,200	34,360,800	5,126,300	18.4	0.1	2.8%	3.1%	183.5%	27.7%
JR Simplot – Pocatello ID		326,000	69,002,173	662	215,812,000	194,230,800	8,983,536	4,880,250	13,451,800	2,007,100	15.3	0.1	2.3%	2.6%	149.7%	22.3%
Texasgulf – Aurora NC		1,394,000	145,649,389	662	922,828,000	812,671,200	37,568,800	17,280,800	57,560,100	8,638,400	12.7	0.1	1.9%	2.1%	154.0%	23.0%
SUB-SECTOR TOTAL		12,280,000	2,279,724,529	662	8,108,000,000	7,290,000,000	337,582,742	213,169,800	629,008,700	93,796,300	17.4	0.1	2.6%	2.9%	186.0%	27.8%
SECTOR TOTAL – PWW AND PHOGYP		6,774,000	2,288,321,162	662	3,822,288,000	3,440,148,200	159,118,062	378,204,800	1,648,318,800	230,730,000	66.7	0.2	9.9%	11.0%	871.9%	146.0%

SUMMARY OF COMPLIANCE COST RATIOS
INCREMENTAL SUBTITLE D-PLUS COSTS TO BASELINE

Commodity Sector	Number of plants producing commodity	Production (MT/YR)	Waste generated (MT/YR)	Unit value ($/MT)	Value of shipments ($/YR)	Value added ($/YR)	Investments ($/YR)	Incremental Compliance costs ($/YR)	Total capital compliance costs ($)	Annual capital compliance costs ($/YR)	Costs per metric ton of product ($/MT)	Costs per metric ton of waste ($/MT)	Costs per value of shipments (percent)	Costs per value added (percent)	Total capital cost/capital investments (percent)	Annual capital cost/capital investments (percent)
Titanium Dioxide																
Entire Sector	8															
Facilities Generating Special Waste	8															
DuPont – New Johnsonville TN	(TiO2)	249,470	110,160	2,200	[illegible]	[illegible]	27,000,000	141,700	7,613,000	1,180,800	0.6	1.2	0.0%	0.0%	28.0%	4.3%
SCM Chemicals – Ashtabula OH	(TiO2)	107,948	61,120	2,200	[illegible]	188,440,000	11,000,000	623,300	7,256,000	1,079,100	5.8	12.2	0.3%	0.3%	61.1%	9.1%
Kerr-McGee – Hamilton MS	(TiO2)	77,111	38,025	2,200	170,000,000	134,200,000	8,500,000	866,000	3,018,400	466,400	11.6	24.3	0.1%	0.7%	38.0%	6.3%
Timet – Henderson NV	(Metal)	12,781	88,460	11,023	148,000,000	134,120,000	7,000,000	1,540,250	6,044,000	891,500	121.3	30.6	1.1%	1.1%	86.0%	14.2%
SECTOR TOTAL		NA	297,884	NA	1,089,000,000	880,840,000	84,000,000	3,201,000	24,782,700	3,857,000	NA	12.6	0.2%	0.2%	45.2%	6.7%
Zinc																
Entire Sector	4															
Facilities Generating Special Waste	1															
Zinc Corp of Amer – Monaca PA		72,000	129,944	1,323	98,314,400	43,341,480	7,222,342	1,088,300	5,488,800	817,280	14.6	8.4	1.1%	2.4%	48.0%	7.2%